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THE SANTEE RECREATION PROJECT, SANTEE, CALIFORNIA

John C. Merrell, Jr., et al

Federal Water Pollution Control Administration
Cincinnati, Ohio

1967

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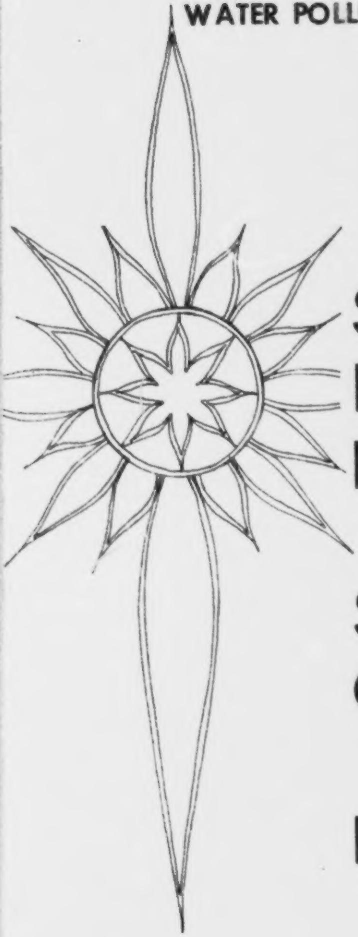

SANTEE RECREATION PROJECT

SANTEE, CALIFORNIA

Final Report

U.S. DEPARTMENT OF THE INTERIOR

Federal Water Pollution Control Administration

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THE SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

FINAL REPORT

John C. Merrell, Jr., William F. Jopling,
Roderick F. Bott, Albert Katko, and
Herbert E. Pintler

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Cincinnati, Ohio
1967

In its assigned function as the Nation's principal natural resource agency, the United States Department of the Interior bears a special obligation to ensure that our expendable resources are conserved, that renewable resources are managed to produce optimum yields, and that all resources contribute their full measure to the progress, prosperity, and security of America — now and in the future.

The WATER POLLUTION CONTROL RESEARCH SERIES of reports was established to describe the results of research studies of water pollution. This SERIES provides a central source of information on the intramural research activities of the Federal Water Pollution Control Administration in the U. S. Department of the Interior and on the research program's cooperative and contractual activities with Federal, State, and local agencies, research institutions, and industrial organizations.

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Water Pollution Control Research Series Publication No. WP-20-7

PARTICIPANTS

The objectives of this study were originally outlined by Roderick F. Bott, Public Health Engineer, San Diego County Department of Public Health; Edward A. Reinke, Chief, Bureau of Sanitary Engineering, California State Department of Public Health; and Paul W. Eastman, Regional Program Director, Francis M. Middleton, formerly Chief, Advanced Waste Treatment, Basic and Applied Sciences Branch, Paul W. Kabler, formerly Acting Deputy Director of Research, Basic and Applied Sciences Branch, all of the U.S. Public Health Service, Division of Water Supply and Pollution Control (now the Federal Water Pollution Control Administration, U. S. Department of the Interior).

The study plan was evolved and set forth in a Memorandum of Understanding among six cooperating agencies: U. S. Public Health Service, California State Department of Public Health, California State Department of Water Resources, California State Department of Fish and Game, San Diego County Department of Public Health, and the Santee County Water District.

An Advisory Committee was established to represent these several agencies and also the California Water Quality Control Board, and the San Diego Regional Water Quality Control Board. This Committee provided continued assistance in planning and operating the project with John C. Merrell, Jr., U. S. Public Health Service, Division of Water Supply and Pollution Control as Project Coordinator. Membership of the Advisory Committee has included:

U. S. Public Health Service
Division of Water Supply and Pollution Control
    Paul W. Eastman, Regional Program Director
    John C. Merrell, Jr., Project Coordinator

California State Department of Public Health
    Frank M. Stead, Chief, Division of Environmental Sanitation
    Edward A. Reinke, Chief, Bureau of Sanitary Engineering
    Paul C. Ward, Supervising Sanitary Engineer, Bureau of Sanitary Engineering
    Harvey I. Magy, Vector Control Specialist, Bureau of Vector Control
    Arnold E. Greenberg, Chief, Sanitation and Radiation Laboratory
    Remo Navone, Chief, Southern California Laboratory
    William E. Reynolds, M. D., Chief, Research Training
    Henry Renteln, M. D., Head, General Epidemiology Section

California State Department of Water Resources
    Arthur Innerfield, Water Quality Specialist
    David B. Willets, Supervising Hydraulic Engineer
    Mitchell Gould, Supervising Hydraulic Engineer

California State Department of Fish and Game
Jack Fraser, Water Projects Coordinator
Lee Miller, Fisheries Biologist

California State Water Quality Control Board
Paul Bonderson, Executive Officer

San Diego Department of Public Health
J. B. Askew, M. D., Director
Roderick F. Bott, Public Health Engineer

Santee County Water District
Ray L. Stoyer, Manager

San Diego Regional Water Pollution Control Board
Dennis A. O'Leary, Executive Officer

Many others from the staffs of these cooperating agencies have contributed to field and laboratory data collection and analyses. The early biological analyses was also assisted by personnel of the Testing and Control Division of the San Diego Utilities Department.

The principal author of this report was the Project Coordinator, John C. Merrell, Jr. W. F. Jopling, Associate Engineer, California Department of Public Health prepared the section on the Swimming Program, and R. F. Bott, Public Health Engineer, San Diego Department of Public Health, prepared the section on Virology and Bacteriology. Albert Katko, Biologist for the Santee Project, along with Herbert Pintler, Region IX Biologist, prepared the section on Biology. Contributions were received from Lee Miller, Fisheries Biologist, California State Department of Fish and Game, and Harvey I. Magy. Senior Vector Control Specialist, California State Department of Public Health.

The Santee County Water District, under guidance of its Manager, Ray L. Stoyer and his Board of Directors, provided the facility for this study. The District provided the lakes and a laboratory building, and also assisted in all sample collection.

Finally, the residents of Santee not only supported the creation of the lakes but participated in all phases of recreation experiment through the swimming experience of 1965. The acclaim which has attached to the acceptance of swimming at Santee enhances the value of the total experiment.

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ABSTRACT

This report presents the results of a study of the Santee, California recreational lakes.

The Santee lakes were deliberately planned to utilize the community's reclaimed sewage effluent. By the summer of 1965, a special basin adjacent to one of the lakes was supplied with reclaimed water and used for swimming. ~~This was~~ found possible after progressive use of the ~~lakes for~~ boating and ~~then for~~ fishing.

~~The~~ seven-agency cooperative study evaluated the ~~fate of virus~~, total and fecal coliform, and fecal streptococci as waste water passed through conventional secondary treatment processes, the sand filtration, and the recreational lakes. Correlative physical, chemical, and biological data have also been obtained on the study of the lakes and related land area. Observations related to the eutrophication, vector control, epidemiology, and the social acceptance and ecology of the entire recreational park were also obtained.

It was found that the additional treatment provided by intermittent sand filtration met most of the requirements for recreational use of the terminal ponds. No health hazards ~~have been~~ demonstrated by the viral or other findings, and this fact had considerable impact in the promotion of public acceptance of the use of the recreational facilities.

SUMMARY

Since 1961 the Santee County Water District of Southern California has successfully operated recreational lakes supplied with a reclaimed waste water developed from the effluent of the community's secondary sewage treatment plant. This is a report of the cooperative study that was established as a requirement for the intended recreational use. Tertiary treatment as required by the State and the County Health Departments has proved to be effective as a barrier in the control of virus in the lake waters even though large viral concentrations in sewage were generated in the community by the feeding of Sabin oral polio vaccines at one period of the study. The tertiary soil treatment system employed has also been effective for the control of nutrients at levels acceptable for both esthetic enjoyment and continuing fish production and propagation at the lakes in spite of the shallow aquifer and limited under-ground water movement. The large reductions in organic material obtained in the conventional activated sludge treatment process emphasize the necessity for effective treatment ahead of the polishing processes. The oxidation pond following secondary treatment provided little treatment in relation to land area used, but it did provide reductions in virus identifications and removals of nitrogen, alkalinity, and bacteria.

The recreational uses established for the Santee Lakes were gradually increased from passive activities such as boating and picnicking in 1961 to a fishing program in 1964. In 1965 appropriate facilities were constructed in an area set apart for swimmers adjacent to one of the lakes, and the reclaimed waters were subsequently used for swimming with additional treatment. All of the recreation programs have been accomplished with full knowledge of the water's origin by the participants. Visitor counts have increased each year to a peak of 75,000 visits in 1965. Over 3200 people registered for swimming. Proper management of esthetics in the recreational lake area has resulted in widespread public acceptance by both local residents and visitors.

The virology study demonstrated the presence of virus in all sewage samples as well as the absence of virus in all samples tested of the treated recreation waters. This virology study also provided the convincing evidence necessary to gain the approval of the public health agencies and epidemiological specialists for the fishing and swimming activities.

The bacterial record of coliform, fecal coliform and fecal streptococci showed appreciable bacterial counts (1,000/100 ml) in the lakes but usually at ratios not normal for direct sewage contamination. Some of the increase in concentrations of these organisms in the recreational lakes resulted from birds but some of the increase can be related to regrowth.

Changes in the kinds of phytoplankton and their biomass have been observed and recorded during the gradual enrichment of the

recreational lakes. The most detrimental of the changes led to a fish kill in the summer of 1965 and the gradual progression of blue-green algal dominance through all of the downstream lakes. The developing biota following impoundment of the lakes had a beneficial effect on the public acceptance of the concept of reclaimed water use, providing an excellent fishery, and a beautiful land and water park environment. With flows now available for supply to the lakes the biological investigations show a need for control of both the blue-green algae and the occasional excess oxygen demand of stored organic materials. The fishery exerted good control of aquatic insects within the lakes.

CONCLUSIONS

The Santee Recreation Project has demonstrated the feasibility and social acceptability of using water reclaimed from sewage as a supply for recreational lakes. The study has further determined that under the treatment provided at Santee the recreational lake waters were free of measurable virus concentrations even though virus isolations were made from all samples of raw sewage and from 95 per cent of the samples of secondary effluent. Under additional treatment to meet the water quality standards of outdoor swimming pools, the reclaimed water was used safely for swimming. The public acceptance of this swimming program by more than 3200 registrants has focused national attention on the project.

The study also demonstrated that nutrients can be controlled to create a balanced producer-consumer chain that supports seven species of fish. However, there is a need to control the enrichment process for continued fish propagation.

INTRODUCTION

The Santee Recreation Project was designed to determine in the field the optimum procedures necessary to manage water quality through a waste treatment and water reclamation system supplying water for recreational lakes. This research project resulted from the need of the County and State Health authorities for information about the presence of viruses in reclaimed waters when the Santee County Water District proposed to use its well-treated sewage effluent as a water supply for recreational lakes. The studies, as finally incorporated in the project, were broadened to include along with virus identification, related chemical, physical, and bacteriological pollution indicators as well as an epidemiological record. Separate studies of hydrology, vector control, fish propagation, and aquatic biology were also set up to make more effective use of correlating data obtained originally for the virus study.

The Santee lakes were created to provide a recreational facility using reclaimed water from the community's own sewage treatment plant. The lakes have been used since 1961 for several recreational activities, limited initially to picnicking and boating and progressing through a "Fish for Fun" program to a normal fishing program suspended only during the spawning season. A basin adjacent to one of the lakes was built and used for swimming during the summer of 1965. The public's acceptance of the reclaimed water thus used for recreational purposes was accomplished under the surveillance and assistance of seven agencies. These included:

San Diego County Department of Public Health
California State Department of Public Health
California State Department of Water Resources
California State Department of Fish and Game
California State Water Quality Control Board
Santee County Water District
United States Public Health Service, Division of Water Supply and Pollution Control (now the Federal Water Pollution Control Administration, U. S. Department of the Interior)

The San Diego Department of Public Health granted approval for non-water contact recreational use in April 1961, with the provision that a study of viruses in waste water be started. A chronology of significant events since then follows:

May	1961	Study requested by San Diego County Health Department
June 24,	1961	Lake No. 4 (see Fig 2) opened for use under County Health Department Jurisdiction
June	1961	Study Program outlined by three health agencies. Fish planted in Lakes No. 3 and No. 4

November	1961	Plans for Santee Water Reclamation Study completed. Advisory Committee formed.
February	1962	First quarterly sampling. All flow to percolation area
March	1962	Vector Control Study started
April	1962	Memorandum of Understanding between six cooperating agencies adopted. See Appendix A-1
April	1962	Spreading area changed from ridge and furrow to six ½-acre beds. Virus study contract approved between California Water Quality Control Board and San Diego County Department of Public Health
July	1962	First virus samples obtained
August	1962	Public Health Service biologist on duty at Santee
January	1963	Advisory Committee agreed on operating changes for second year and general plan for epidemiological study
March	1963	Operations changed to divert part of the flow from Oxidation Pond 1 to Pond 2 with chlorination. Spreading area out of service
April	1963	Spreading Basin returned to service, receiving part of the flow from Pond 1 without chlorination. Spreading area fenced, chlorine contact chambers added at Lake 4 and Pond 2 inlets. Fish for Fun program started.
May	1963	Successful bass spawning observed
June	1963	Laboratory building completed
July	1963	Pilot epidemiological survey started
May	1964	Epidemiological advisory committee appointed
June	1964	Fishing program changed to allow consumption
August	1964	Epidemiological Committee recommended swimming be permitted in separate swimming area
November	1964	Attenuated Polio Type 3 used to test effectiveness of percolation bed
March	1965	Spreading area changed to provide cross valley flow with 400 ft. minimum underground travel
May	1965	Swimming area completed and fenced
June	1965	Swimming program opened. **Tilapia** planted in Lake No. 2
September	1965	General fishkill in Lakes No. 2, No. 3, No. 4 due to oxygen depletion

SWIMMING EXPERIMENT COMPLETED

The first three years of joint studies at Santee provided evidence of the viral and bacterial safety of the water supply for the lakes. This evidence was evaluated by a special ad hoc Epidemiological Committee reporting to the State Director of Public Health. This Committee recommended that the State Director move ahead with the swimming program in the reclaimed waters, further treating the waters to meet water quality requirements of outdoor swimming pools in California.

This assurance of public health protection, combined with continued surveillance of the health and pollution control agencies, assisted the Santee County Water District in gaining enthusiastic public acceptance of the swimming program. This demonstration that the public will knowingly and intimately associate with water reclaimed from sewage in a carefully planned and maintained facility is considered a major project accomplishment. National and even international attention has been drawn to the premise that water renovation and monitoring technology, as currently available, can solve similar and larger problems in pollution control and supplementary water supply elsewhere.

Previous Santee Project reports (1, 2, 3) have summarized bacterial, chemical and biological results obtained during the first three years. These reports also presented the virological data then available. This report is a final summary of all virological examinations including a detailed account of the swimming experience of 1965, plus a summary of all chemical, physical, bacteriological and biological examinations of the Santee Lakes as they relate to the developing eutrophication and recreation use.

RECREATIONAL LAKES

The unincorporated community of Santee lies along the San Diego River Valley for a distance of 6 miles, beginning approximately 15 miles above the river mouth. It is just north of the City of El Cajon and about 20 miles by road from downtown San Diego. The community is largely residential with only a few commercial establishments essential to community needs. There is no waste-producing industry.

Sycamore Creek, a tributary of the San Diego River, extends generally northward from the San Diego River channel and forms a canyon containing both the community treatment plant and the recreational lakes. There is subsurface flow in Sycamore Canyon but only occasional surface flow.

Here five lakes were created by the Santee County Water District to utilize the high quality waste water from the sewage treatment plant in the Sycamore Valley area after water-bearing materials had been mined for sand and gravel. The lakes were formed by regrading the remaining spoil area into dykes and appropriate land-water configurations. The lake bottoms contained some residual sand and gravel on an impervious clay layer which slopes up-valley on about a 1 per cent grade. The lakes average about 1000 feet in length and their depths vary from 10 feet at the deep end to about two feet at the shallow end. Figure 1 is an aerial view of the total valley area showing the lakes in use during 1965, as well as the housing and residential area immediately adjacent to the lakes. The lakes are numbered in sequence up the valley for the orderly creation of new lakes. An isometric schematic view of the lakes is shown in Figure 2. Lake 5 at the upper end of the series was first filled in 1965 and it currently receives the first recovered flow from the percolation area in the valley upstream. The swimming area is adjacent to this lake. Lakes 4 and 3 have been used since 1961. They were operated in series, Lake 4 being the first to receive the recovered flow until Lake 5 was developed. Lakes 4 and 3 are now downstream from Lake 5 in the series. Lake 2 receives flow from Lake 3 but serves no recreational function. It has been used for fishery experiments. The No. 1 Lake in the extreme downstream position has been operated as an oxidation pond

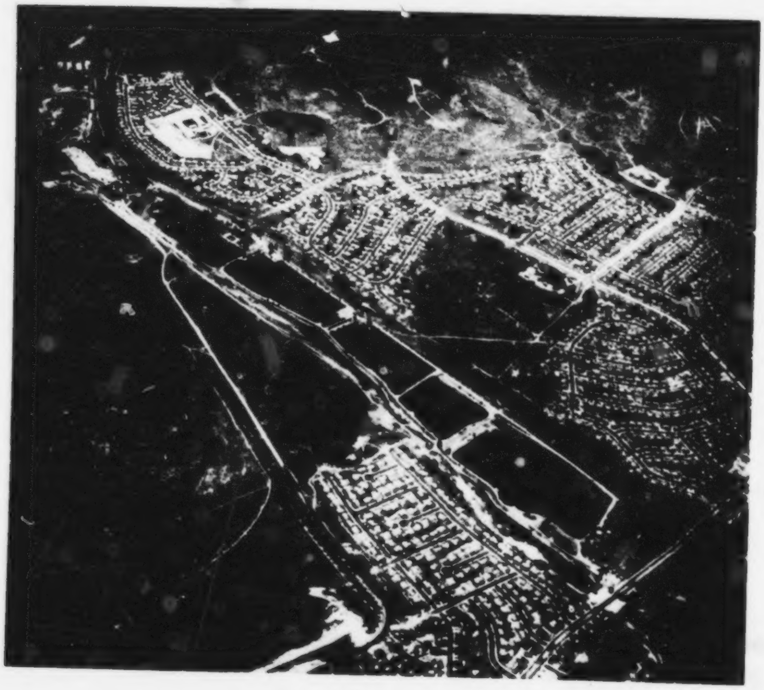

Figure 1 — Aerial view of Santee Project Area.

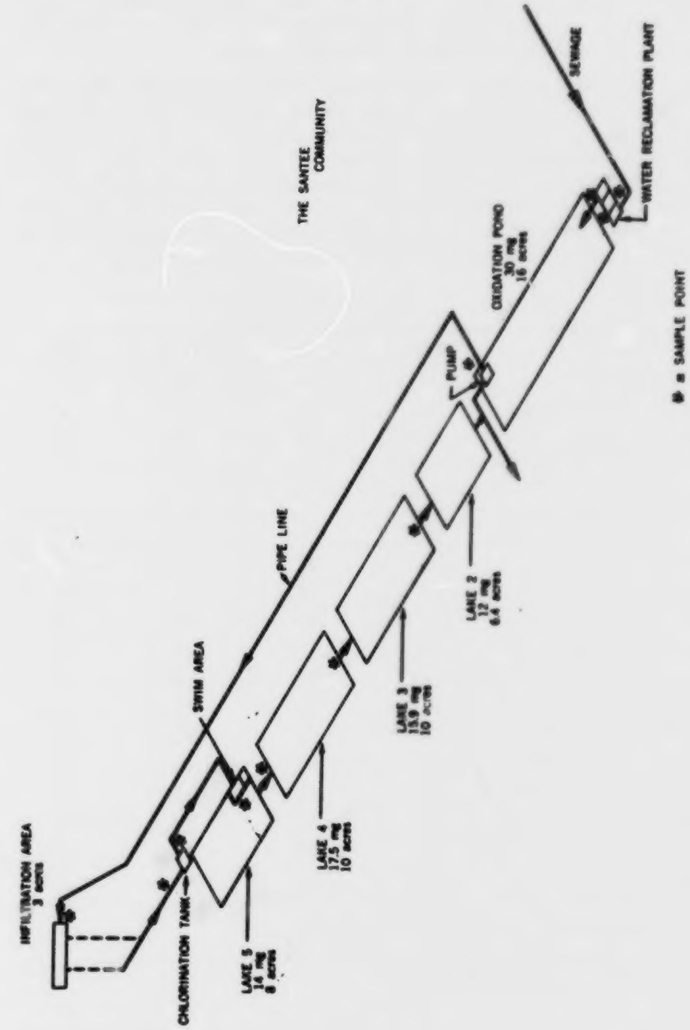
INFILTRATION AREA
3 acres
CHLORINATION TANK
LAKE 5
14 mg
8 acres
LAKE 4
17.5 mg
10 acres
SWIM AREA
PIPE LINE
LAKE 3
15.9 mg
10 acres
LAKE 2
12 mg
6.4 acres
PUMP
OXIDATION POND
30 mg
16 acres
THE SANTEE
COMMUNITY
WATER RECLAMATION PLANT
SEWAGE
⊕ = SAMPLE POINT

Figure 2 — Schematic view of the Santee Project.

receiving effluent from the activated sludge treatment plant. Approximately one-third of the oxidation pond effluent is pumped to a spreading area one mile upstream of the lakes, from which it percolates down valley to supply the lakes. The other two-thirds of the effluent flow is chlorinated before discharge to the nearby stream and subsequent downstream irrigation of a golf course.

Recovery of reclaimed waste water from the aquifer above the lakes constitutes the primary water supply for the lakes, although infrequent heavy rains develop natural ground water or runoff to slightly supplement the supply. During late 1965, heavy rains caused considerable runoff with flows reaching several hundred cubic feet per second. Very little of this natural flow was added to the lakes because of the limited inlet structures. Table 1 summarizes flows of both sewage effluent and reclaimed water supplied to the lakes.

Table 1 — FLOW DATA — mgd

	1962	1963	1964	1965
Treatment Plant	0.90	.95	.90	1.2
To Percolation Area	.72	.40	.29	.22
Inlet to Lakes	.7*	.34	.27	.43*

(Lake Inlet by Months)

	1962	1963	1964	1965
January	NR	.60	.25	.27
February	1.00*	.55	.25	.31
March	NR	.40	.40*	.22
April	NR	.17	.34	.7*
May	0.95*	.27	.34	.52*
June	.65	.27	.25	.40*
July	.63	.25	.28	.33
August	.59	.20	.22	.31
September	.60	.25	.25	.28
October	.61	.40	.27	.28
November	.61	.40	.23	.36*
December	.62	.34	.22	1.17*

*Includes 10% or more natural runoff.
Inlet flow changed from Lake 4 to Lake 5 on 4-2-65.
NR — No record.

During the winter months, the lakes have discharged in series downstream at an average flow of 0.3 to 0.4 million gallons per day (mgd) sufficient to offset seepage and evaporation losses. During summer months when the major portion of the five-foot annual evaporation loss occurs, all of the inlet flow to the upstream two lakes is lost. The surface area and volume of the recreational lakes are shown in Figure 2.

The master plan for development of the canyon provides for a flood control channel along the westerly boundary and a freeway along the easterly edge of the canyon. The several recreational lakes will ultimately be located between these facilities. New lakes will be built up the canyon as additional spoil areas are created. The recreational area now totals 60 acres of which approximately one-half is water surface in the lakes. Investment in the recreational lakes at the end of 1965 totaled $250,000. This community asset represents a reclaiming of both land and water. The water reclamation was possible by combining man-made technology (the sewage treatment plant) and the natural (soil system) treatment processes.

Treatment Facilities

The Santee County Water District is a public agency that provides water for the district's 13,000 people, and in addition it operates the sewerage facility for the same area. The sewage has been treated in an activated-sludge-type sewage treatment plant of 2 mgd design capacity. The entire sewage treatment and water reclamation process consists of the following units:

Unit	Design capacity, mgd
Raw sewage lift station — comminuter, bar screen 2 pumps: No. 1, 2,200 gallons per minute (gpm) No. 2, 2,800 gallons per minute (gpm)	4
Primary Clarifier, 45 ft i.d., 95,000 gal vol	2
Sludge Digester, 45 ft i.d., 50,000 ft³ vol	2
Activated Sludge, 67 ft i.d., 380,000 gal vol, 3 blowers 245 cfm each, 1 mixer and surface aerator with 60 hp motor	2
Oxidation pond, 16.0 acres, 30-million-gallon volume, Elev. 323 ft at water surface	
Transfer pump 1,160 gpm — 60 hp — 41 psi	
Transfer line 12 in. A.C. — 7,700 ft	
Spreading area-elev 395 ft. 6 basins 100 × 200 ft area — 3 acres	

Flow measurements are made from hour meters on the pumps and by rectangular weirs. The plant has often been operated with a return flow from the Oxidation Pond to the main trunk sewer ahead of the lift station. Waste activated sludge is also returned to this sewer. Supernatant flow from the digester can be returned to the primary unit, diverted to the oxidation pond (as it was during August through November 1962), or treated in a separate extended aeration tank.

Flow from the Oxidation Pond can be chlorinated prior to pumping to either Pond 2, Sycamore Creek, or to the spreading area 8,500 feet upstream. Until April 1963, chlorination was only required for flow from Pond 1 to the spreading area. All flow not pumped to the spreading area has been chlorinated prior to disposal from the project area. The large portion of flow leaving the project has been used for irrigation of a nearby golf course.

The alluvial fill in Sycamore Canyon that has been exploited for sand and gravel material has also provided the treatment system that made the recreation lakes possible. Recreational use of the reclaimed waste waters was permitted only after the Santee County Water District proposed to use the spreading area with underground percolation in addition to its regular treatment system. The alluvial fill is only 12 to 15 feet deep and is deposited over sedimentary bedrock composed of siltstone and clayey sandstone which serve to confine the underground stream. In 1962 the spreading area contour was changed from a series of eight trenches across the valley to a series of six one-half acre basins, and in 1965 to a new series of six 50 × 300 ft. beds along the east side of the valley. Considerable difficulty has been experienced with the spreading area due to the low permeability and Sycamore Canyon's slight hydraulic grade. During the first year, it was the practice to pump all flow to the basins for 1 or 2 days and then shut off for as long a period as possible to allow the beds to dry. Since then, pumping to the basins has been limited to permit intermittent spreading and drying.

In 1962 the California Department of Water Resources investigated the flow capacity of the aquifer (Appendix B1). Using test holes to bedrock and one per cent measured ground water slopes above the spreading area, the underground basin capacity, when there was surface flow, was estimated at 100,000 gallons per day (gpd). Project records of recovered underground flow show that the true under-flow capacity was 150,000 gpd. Minimum natural underflows during extended dry periods were found to be less than 20,000 gpd. Since waste water flows applied to the infiltration area have exceeded the transmissibility of the underground aquifer, some percolated flows have formed surface streams about 200 ft. below the spreading area. These streams were deepened to increase the hydraulic gradient to as much as 4 per cent and assist in removing water from the ground water mound at the spreading area. As the gravel removal advances upstream, the collection gallery or dewatering cut off trench is also frequently moved upstream. Since treatment effectiveness varies with distance of travel to the collectional gallery, the spreading area was moved in 1965 to a location along the east side of the valley. The cut-off trench was placed 400 ft. distant along the west side of the valley where it can act as a collection gallery and also a bypass channel for flood flows. With this arrangement the percolating flow is about four days in residence underground.

Soil samples from the spreading area showed effective sizes of 0.17 to 0.37 millimeters and uniformity coefficients of 2.5 to 5.5. The spreading basins have reflected this variation in their unequal rates of drying. The District has tried to equalize rates of drying by applying flows to the beds in the amount that can be infiltrated each day.

Routine scarification at 3 to 4 month intervals has been used to prevent ponding in each bed.

RECREATIONAL PROGRAM

In 1959 the community of Santee was faced with the alternative of abandoning its existing sewage treatment and joining the San Diego Metropolitan System with ocean disposal of treated effluent, or providing additional treatment at its year old treatment plant and justifying the added cost by putting the waste water to beneficial use. The District first planned to make recreational use of the reclaimed waters after passage through a series of three stabilization ponds. When the San Diego County Department of Public Health rejected this plan, the District proposed to include percolation and chlorination of the oxidation pond effluent using the natural aquifer available in Sycamore Canyon.

Preparation of the first recreational lake with its adjacent grassed areas served as an example to the local public of the pleasant appearing oasis that could be created in an otherwise wasted and arid area. Natural rainfall in the Santee area is concentrated in the winter and spring and normally produces a winter growing season that adds a touch of green to the surrounding country. During the rest of the year, or in a dry year, the natural grasses remain brown and add to the area's arid character. The induced green areas surrounding the lakes and the lakes themselves have effectively invited public interest and support. Santee's climate, typical of the Southern California near-coastal area, added further impetus to the recreational program. The hot, dry summers invite water oriented recreation, and the ocean as a recreation area is not available to many. A typical summer day at Santee is sunny with occasional early morning low clouds that disappear by noon. Winds generally from the west are favorable for sailboat activity. Daytime temperatures are suitable for outdoor recreation in all seasons. A weather record summary for Santee is presented in Appendix B2.

Since 1961 the recreational program at Santee has progressed from simple esthetic enjoyment of the lakes to picnicking, boating, through a season of "fishing for fun" to fishing which permitted fishermen to keep and eat their catches. Finally, in June 1965 a swimming area at Lake No. 5 was opened. The park is often used for special group activities. The lakes are open from 11:00 a.m. until dark during all weekends and holidays year round and daily during summer while the schools are closed.

Use of the Santee lakes has increased each year since the first opening event in June of 1961. Entry counts in 1964 showed that 50,000 visitors came to the area that year. The Santee County Water District estimated that at least 75,000 people used the facilities during 1965. The lakes are the base for what has now become the annual Santee Lakes Festival, and, along with the adjacent golf course which also depends on reclaimed water, they form the major recreational facility for the entire Santee community. The records indicate that many people from adjoining communities, including the City of San Diego, also use these facilities.

The first three lakes (#2, #3, and #4) represent an investment of $125,000. Lake No. 5 and the associated picnic, island and swimming area development and facilities required an additional $125,000. There are no entrance fees for lake use, but the District does plan to charge for future swimming activities. Many people, both children and adults waited as long as three hours to be admitted to the swim area in the **1965 season, waiting in line in plain view of the sign shown in Figure 3.**

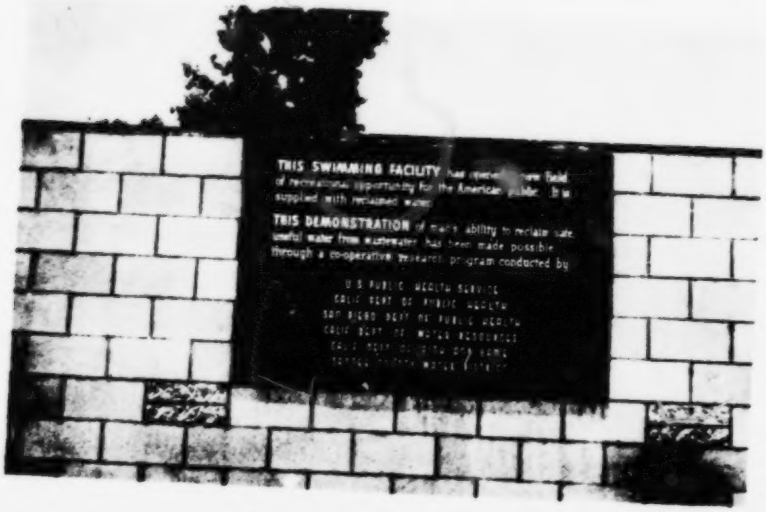
THIS SWIMMING FACILITY has opened a new field of recreational opportunity for the American public. It is supplied with reclaimed water.
THIS DEMONSTRATION of man's ability to reclaim safe, useful water from wastewater has been made possible through a co-operative research program conducted by
U S PUBLIC HEALTH SERVICE
CALIF DEPT OF PUBLIC HEALTH
SAN DIEGO DEPT OF PUBLIC HEALTH
CALIF DEPT OF WATER RESOURCES
CALIF DEPT OF FISH AND GAME
SANTEE COUNTY WATER DISTRICT

Figure 3 — Sign at swim area.

Experimental Swimming

After the recreational facility for boating, fishing and shoreline activities had been in use for three years, an ad hoc Advisory Committee on Epidemiology was appointed by the California State Department of Public Health in May 1964, to review the past program of non-contact water use and to advise the Department on the risks, if any, in body contact use of the reclaimed water. The Committee, in particular, was to evaluate the feasibility of establishing a swimming area. After reviewing the information from the previous two years of study, the Committee sanctioned the swimming program if, among other conditions, the swimming area was developed and maintained to meet the State of California's established water quality standards for artificial pools. The Committee emphasized that its recommendation was conditioned upon maintenance of strict safety and sanitary regulations, and that filtration through the soil must continue to be a part of the water reclamation process.

Later in the year the Water District, which had been informally pursuing the concept of a swimming facility at the reclamation project, advised the Department of Public Health that it would be necessary to reduce the natural filtration zone to a minimum length of 400 feet. A November 1964 study by the Bureau of Sanitary Engineering and the San Diego County Department of Public Health determined the effects that such a reduction in the filter zone would have on reclaimed water quality. As part of the study, the filtration zone was subjected to a massive dose of attenuated Type 3 polio virus, as reported under Virology. The major reduction in bacterial concentration occurred within the first 200 feet of filtration. Chemical analyses indicated that high percentages of phosphate, detergent, and certain nitrogen forms in the percolating liquid traveled more than 200 feet. These constituents could create problems of foaming and algal growth in the lakes, if not in a swimming pool.

In February 1965, the Santee County Water District formally proposed to construct a flow-through swimming facility which would blend in with the other recreational facilities and which would use reclaimed water. With the understanding that the swimming facility was to be operated on an experimental basis with constant monitoring of water quality and pool operation, variances in standard structural requirements for a public pool were allowed.

The Santee experimental swimming basin, as first constructed (see Figure 4), was a shallow pool with depths of 1½ ft. at the inlet end and a maximum of 3½ ft. near the opposite end. A straight low concrete wall formed the inlet side of the pool. Reclaimed water entered through multiple ports along the bottom of the wall. The other three sides had a 5:1 slope and were formed of sand over a soil-cement base, as was the pool bottom. The pool water was continuously discharged to recreational Lake 5 through a bottom drain and two skimmers. There was no recycling of water back through the pool. Pool capacity was approximately 80,000 gallons, and the dimensions at the water line were 65′ × 87.5′.

The requirements for operation during the trial swimming program established by the State and San Diego County Health Departments are given in Table 2.

Table 2 — REQUIREMENTS FOR SANTEE EXPERIMENTAL SWIMMING AREA OPERATION

1. Pool water quality must meet the State Swimming Pool Standards for the quality of water in artificial pools.
    a. Pool turnover — 8 hours maximum
    b. Not more than 15% of samples shall have:
        (1) Plate count more than 200 per ml
        (2) Coliform bacteria in any of five 10 ml portions

   c. Clarity — a 6″ black disc on a white background shall be visible at the deepest point from 10 yards
   d. pH — 7.2 to 8.4
   e. Minimum chlorine residual — 0.4 free or 0.7 combined

   The swimming basin will be immediately closed to use at any time that water quality requirements are not met.

2. Ten days of satisfactory operation, supported by laboratory data, must be obtained prior to opening of the swimming basin to the public.
3. The bathing load shall be controlled. During the first 10 days of use, no more than 25 bathers may use the basin at one time. If suitable sanitary conditions are met with 25 bathers, the load may be increased to 50 persons during the next ten days. If no water quality problems then arise, the basin may be opened to capacity.
4. Until it has been determined that a lesser sampling program is indicated, bacteriological samples will be taken twice daily from several points in the basin.
5. Virus samples are to be obtained from inflowing and outflowing water at the swimming area.
6. All persons using the pool must be registered by name, age, address, date, and time of day of entrance to the pool. The registration shall be maintained as a permanent record.
7. Swimming will be prohibited if apparent illness results from the operation of the swimming program.
8. A qualified lifeguard is to be in attendance at all times that the swimming basin is in use.
9. A sign will be placed at the swimming site which states that the swimming area contains reclaimed water.
10. Natural filtration must be included as part of the reclamation process.

In order to determine that the water quality consistently met the State Swimming Pool Standards for quality of water in artificial swimming pools, a temporary laboratory was set up and operated at the Santee reclamation plant by the Bureau of Sanitary Engineering, State Department of Public Health. During the entire trial swimming program, which was conducted with some interruptions from May through September, water samples were collected twice daily from five locations in the pool and were analyzed for coliform bacteria and total plate count. Chlorine residuals were measured amperometrically and by orthotolidine color comparison at the end of the chlorine contact chamber and at the inlet and outlet ends of the pool twice daily along with pH determinations. Spot checks were made at other times. The pool alkalinity, temperature and clarity, as well as water flow, chlorine dosage and weather conditions were also recorded. Frequent observations during each day of operation were made to insure that operational requirements were being met. Continuous virologic sampling and analyses were also carried out by the San Diego County Health Department. The results of these analyses showed no isolations of virus in the swim area waters. Detailed results are shown in the section on Virology.

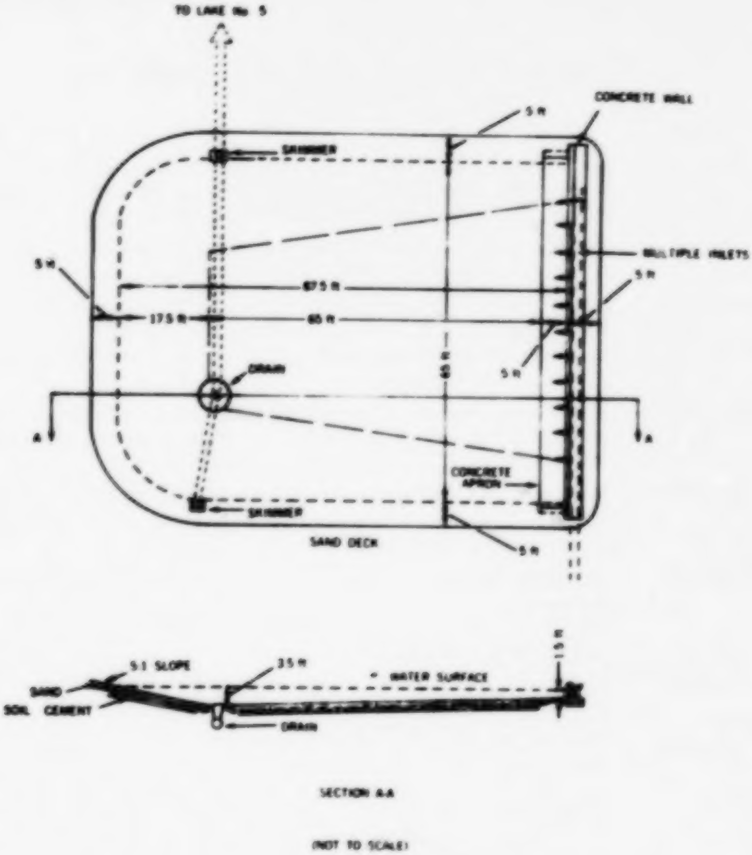
TO LAKE No. 5
CONCRETE WALL
5 ft
SKIMMER
MULTIPLE INLETS
5 ft
5 ft
87.5 ft
17.5 ft
65 ft
5 ft
DRAIN
A
A
CONCRETE APRON
SKIMMER
SAND DECK
5 ft
5:1 SLOPE
3.5 ft
WATER SURFACE
SAND
SOIL CEMENT
DRAIN
SECTION A-A
(NOT TO SCALE)

Figure 4 — Experimental swimming basin plan.

As is indicated in Table 2, the trial swimming program was to be carried out in a series of stages, each to be successfully completed before proceeding to the next. The pool would be operated for 10-day periods, first with no swimmers, then with a maximum of 25 swimmers, and finally with 50 swimmers.

The trial program was interrupted a number of times, due primarily to elements of the swimming basin construction and to the quality of the reclaimed water which resulted in excessive color and/or turbidity in the pool.

The program "highlights" are presented chronologically in Table 3 followed by a brief summary (Table 4) of the water quality records during the different stages of the program.

Table 3 — CHRONOLOGY OF THE SANTEE TRIAL SWIMMING PROGRAM

1965	
May 16	Laboratory equipment was set up at the reclamation plant. The pool had been filled with highly chlorinated water to disinfect the sand sides and bottom.
May 17	The pump to the pool was started but was soon shut down because of turbidity in the reclaimed water.
May 20	After improvements had been made to the collection trench to reduce the excessive turbidity, and adjustments had been made to the pool outlet device, *the first stage of the program began.*
May 25	A meeting was held to review results of the past few days. Approval was given to begin the 25-swimmer stage on June 1, provided that results continued to be good.
May 28	The chlorinator injector became clogged during the night of May 27-28. Low chlorine residuals and positive coliform bacteria resulted.
May 31	The first stage of the program was successfully completed. Because of the cold and overcast weather that had prevailed thus far, the 25-person swimming period was postponed until June 3.
June 3	*The pool was opened to the public;* but because of the cold weather only a few entered the water.
June 6	The required sign was posted stating that the water in the pool was reclaimed from municipal waste water. During this first sunny day, the chlorine dosage had to be increased greatly to maintain a residual in the pool. The pool water became highly turbid due to the sand suspended by the activity of the children in the pool. The District had difficulty controlling the number entering the pool.
June 9	The Water District was required to *close the pool* because of excess turbidity, poor control of swimmers, and positive coliform results.
June 12	*The pool was opened* after a cement grout had been applied over the soil-cement base of the sides and bottom. The pool bottom was recovered with washed sand.

June 14	*The pool was closed* because of excessive color and turbidity which again was attributed to the sand in the pool. A second coat of cement grout was applied, and no sand was placed in the pool.
June 19	*The pool was opened* to swimmers, and the 25-swimmer stage of the program began again. A copper-sulfate feeder was installed at the inlet to the chlorine contact chamber in an attempt to correct a color program which had gradually developed.
June 28	Gravel removal operations below the filtration area caused the reclaimed water to be colored and turbid.
July 2	Alum was fed at the inlet to the chlorine contact chamber in an attempt to remove turbidity. The alum carried over into the pool.
July 6	For most of the time from July 6 to July 16, domestic water was used in the pool because of the excessive color and turbidity when reclaimed water was used.
July 16	At a meeting at Santee, the District was requested to *close the pool* because of the record of turbidity and color, deteriorating coliform bacteria quality, and the unacceptable use of domestic water during the experimental program. The District was requested to determine water treatment needs, install treatment works, and conduct prototype tests to insure that a satisfactory water be produced before the swimming program was resumed.
August 16	The District installed diatomaceous earth filters and operated them successfully for several days. Washed sand was placed back in the pool. Approval was given to resume the 25-swimmer phase of the program.
August 18	*The pool was opened* to the public. Water treatment consisted of coagulation, chlorination, filtration, chlorination, sequestration and pH control. The pool water did not have good clarity and was slightly colored.
August 20	*The pool was closed* while an unsuccessful attempt was made to improve clarity by changing treatment procedures.
August 22	*The pool was re-opened.*
August 27	After being informed that the water quality would have to be improved if the swimming program were to continue, the District removed the sand from the pool bottom and the color and clarity were greatly improved.
August 31	The 25-swimmer phase was successfully completed.
Sept. 1	The 50-swimmer period was started. Except for elimination of the sequestering agent, treatment was the same as shown for August 18.
Sept. 12	The 50-swimmer period was successfully completed and the pool *was closed for the season.*

Table 4 — SUMMARY OF POOL WATER QUALITY

	Coliform Bacteria*		Plate Count**		*** Chlorine Residual (Amperometric)			**** pH Range	Disc Visibility
	No. of samples	% of samples with + tubes	No. of samples	% of samples 200/ml	Max.	Min.	Med.		
No swimmers May 20-31 (12 days)	120	11	120	0	4.7	0.4	1.9	7.1-7.4	No, 3 days
	First stage considered successful; pool opened to 25 swimmers on June 3.								
25 swimmers June 4-9 First try (6 days)	55	15	55	0	7.0	1.4	2.8	6.7-7.4	No, 2 days
	Pool shut down, turbidity, poor control of swimmers.								
25 swimmers June 12-13 Second try (2 days)	20	5	20	0	6.0	2.0	4.1	6.8-7.2	No, 2 days
	Pool shut down, turbidity and color.								
25 swimmers June 19-July 4 Third try (14 days)	140	13	140	1	5.0	3.4	1.7	6.8-7.3	No, 1 day
	Pool shut down, turbidity, color and deteriorating coliform bacteria results.								
25 swimmers August 18-19 Fourth try (2 days)	20	0	20	5	6.0	1.4	3.0	6.8-7.0	No, 2 days
	Pool shut down, turbidity and color.								
25 swimmers August 22-31 Fifth try (10 days)	100	2	95	7	5.2	0.2	1.2	6.9-8.0	No, 5 days
	Second stage considered successful; pool opened to 50 swimmers on Sept. 1.								
50 swimmers September 1-12 (10 days)	100	6	99	9	5.4	0.4	1.9	7.1-8.3	OK
	Third stage considered successful.								

Pool closed for the season after completion of study.

* 15% with + tubes allowed

** 15% 200/ml allowed

*** 0.7 combined residual required

**** 7.2 to 8.4 required

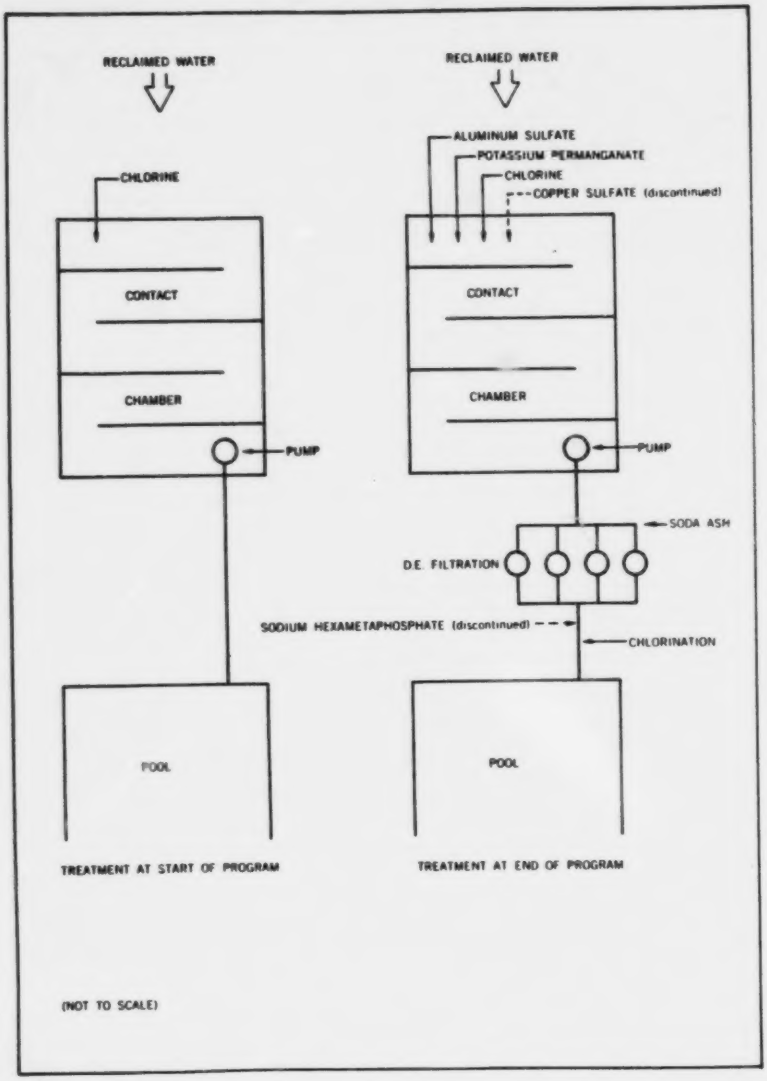
RECLAIMED WATER
CHLORINE
CONTACT
CHAMBER
PUMP
POOL
TREATMENT AT START OF PROGRAM
RECLAIMED WATER
ALUMINUM SULFATE
POTASSIUM PERMANGANATE
CHLORINE
COPPER SULFATE (discontinued)
CONTACT
CHAMBER
PUMP
SODA ASH
D.E. FILTRATION
SODIUM HEXAMETAPHOSPHATE (discontinued)
CHLORINATION
POOL
TREATMENT AT END OF PROGRAM
(NOT TO SCALE)

Figure 5 — Reclaimed water treatment for swim area.

The treatment system for the reclaimed water at the start and end of the trial swimming program is shown in Figure 5.

Turbidity and color in the pool water plagued the Water District for most of the trial swimming program. The color was chiefly attributed to the presence of manganese and iron in the reclaimed water, picked up during the natural filtration step of reclamation. The turbidity was largely due to the sand that was placed in the pool to simulate natural conditions and was also caused by activity along the collection trench which carried reclaimed water to the contact chamber and pool. A light manganese or iron floc was also formed in the pool prior to the installation of coagulation and filtration equipment. The floc would settle overnight but was quickly resuspended by the bathers. Continuing problems with the pool vacuum cleaner prevented daily removal of the deposit.

Eventual removal of the sand from the pool and additional treatment facilities corrected the color and turbidity problem.

It was difficult to maintain consistent chlorine residuals throughout the pool, particularly after the filtration equipment was installed and pre- and post-chlorination was practiced. The residual in the pool after filtration was primarily a free chlorine residual: there was as much as a 4 mg/l loss from the inlet to the outlet of the pool. In spite of chlorine residuals of 5-6 mg/l at the inlet, there were no complaints of eye irritation.

Water samples, particularly from the leeward side of the pool, occasionally had high plate counts and were positive for coliform bacteria. Further investigation revealed that scum and debris such as bird feathers were the cause. The two skimmers could not effectively remove surface scum from all portions of the pool.

Public acceptance of the swimming facility was very good. Even during periods when the District was experiencing difficulty with pool water quality and the water was either turbid or had an unfortunate yellowish-brown color, children brought by their parents eagerly waited their turn to enter the swimming area. The cold weather in June was the only real factor in holding down the number of swimmers. The records showed that more than 3,200 individuals registered for swimming. Over 1,800 were from the immediate Santee area, 1,300 from other San Diego County communities, over 60 from other California communities, and 23 from out-of-State. Approximately 600 local registrants repeatedly used the facility during the swimming program.

In one sense the experimental swimming program at Santee was not successful. It was the District's expressed objective to create benefits through the practice of wastewater reclamation at lower costs than would otherwise be possible. Unfortunately, more extensive treatment was eventually required for the iron and manganese removal and positive turbidity control than would be required for a conventional pool using domestic water and having recirculation. Also, it was not possible to successfully maintain water clarity with the sand sides and bottom.

The program did show that water reclaimed from sewage can be used for a swimming area and can meet the strict water quality requirements for such use. The program also showed that a community that has "grown up" with sewage reclamation readily accepts the use of reclaimed water in a swimming pool.

The Fishery

One of the more popular activities at the Santee Lakes has been the fishing program. A large percentage of the children using the park on weekdays enjoy this activity. Whereas a typical family fishing trip to the Ocean or Colorado River involves preparations of an expeditionary character, the fishing opportunities at Santee are of a "Huck Finn" type and are available close by the residential area. The lakes have been carefully stocked with suitable warm water fish to take advantage of the very productive waters. During the first two years of the Project there was a "Fish for Fun" program, requiring that all game fishes caught (this did not include the sunfishes) be returned to the water, and that the sunfishes be turned over to an attendant for disposal. The first requirement was based on the principal objective of the Santee Recreation Project to determine whether or not these recreational lakes could be maintained and used without exposing the public to possible infection from harmful bacteria and viruses. Thus, no fish were permitted to be eaten until studies proved that the water was safe. The second requirement sought to prevent a buildup of the sunfish populations to the detriment of the game fishes, as happens so frequently in farm ponds containing combinations of warm water fishes similar to the Santee fishery. The requirements of the fishing program were changed after the 1964 spawning season. Fish may now be taken for consumption with catch limits imposed only for bass and catfish.

Since early June 1961, the California Department of Fish and Game at intervals has stocked the lakes with a variety of warm water fishes. A detailed list of all plantings is shown in Appendix B3. In June 1961, adult redear sunfish, threadfin shad and yearling largemouth bass were planted in Lake 4. Six months later, adult channel catfish were also planted there. During the 1961-1962 winter season 19 rainbow trout were put in the lake by District personnel. Lake 3 received plants of Florida largemouth bass, threadfin shad, and channel catfish between June 1961 and October 1962. Additional plantings of largemouth bass, channel catfish were made in Lakes 3 and 4 in 1964. Lake 5 was stocked with only bass and threadfin shad in 1965 in an attempt to establish a simple food chain without panfish.

Follow-up test seinings showed that in addition to the fish species officially planted, Lake 4 supports other species. Bluegill sunfishes are now present. Mosquitofish have also been routinely planted by a mosquito abatement group. Lake 3 contains the same fish species as Lake 4, with the exception of the rainbow trout.

Test seining has been conducted to develop information about growth of fish, distribution of fish, evidence of reproduction and estimates of the standing crop. These seinings show that all of the various species spawned except the channel catfish and the trout, which do not spawn in this type of habitat. Calculated weights of fish production yields were 400 pounds per acre although there has usually been an adverse ratio of pan to game fish. Public response to the fishing program has been good from the beginning.

During the summer of 1964 large numbers of both panfish and game fish were caught daily. Their estimated weight would account for approximately one half of the yield, or 200 pounds per acre. The July 1964 record was typical of monthly catch records: 36 catfish of 12-29 inch lengths, 26 bass of 11-18 inch lengths and more than 1,000 pan fish. Maximum weights for the catfish caught was 6 pounds; for bass, 4 pounds.

In 1964 one weekend a trout was caught indicating that this specie had also survived. In August and September of 1965, a major fish kill occurred in Lakes 3 and 4 due to oxygen depletion following very warm weather. The biological significance of this kill along with other events is discussed further in the biology section. The effective removal of dead fish not only gave an indication of numbers occupying the lakes but was accomplished without stigmatizing the social acceptance of the fishing in these reclaimed waters.

The presence of fish in the reclaimed waters of the Santee Lakes has been exploited by fishing contests and other entertainment and educational functions, such as visits by school children during the spawning season. These events, conducted in a pleasing environment, serve to increase and solidify local support for the project.

Boating, Picnicking, and Other Activities

As the Santee Recreational Lakes were developed, the interest of the public was first generated by the appeal of green lawns around Lake 4. This lake had been planned for boating and picnicking, with some playground equipment installed for children. The local newspaper has provided much publicity and the newspapers of nearby San Diego have also taken note of Santee County Water District's plans and accomplishments. The nearby residents were obviously impressed by the beneficial aspects of the lake and its surrounding park-like grassed area in contrast to the adjacent mined out spoil area left by the gravel removal operation. On April 12, 1961 when the District first requested permission to use Lake 4, the San Diego County Department of Public Health denied approval for any contact by the public until more information could be developed regarding the presence of virus. The District then modified its plan to provide additional treatment and subsequently obtained approval for boating and picnicking. Publicity developed in this interchange actually served to encourage and increase local interest and participation.

Boating was an integral part of the recreation from the first day. Boats are rented by the hour and control of their use has been by District personnel or a concessionaire. Currently boat types include row boats, small sail boats with a center board and paddle boats. (See

Figure 6). One outboard motor boat is used for patrol purposes. Since good westerly winds usually blow each day and are primarily across the lake, good conditions prevail for teaching children to sail. Most boating activity is on Lake 4. Ramps are available in both lakes, but private boats have not yet been used.

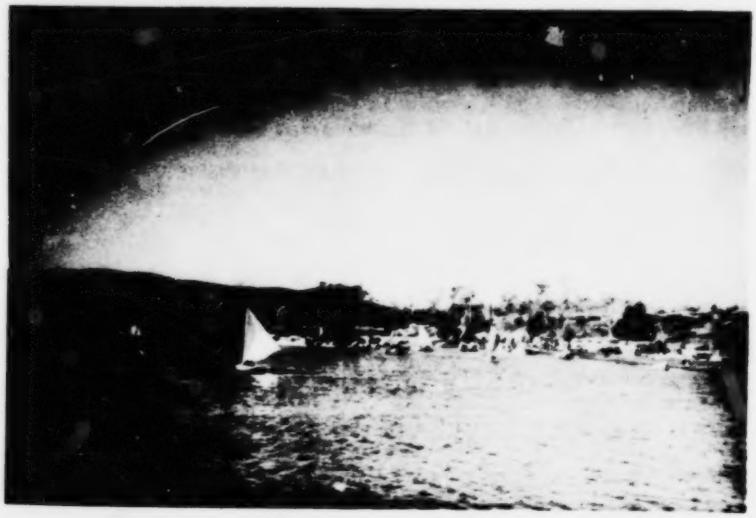

Figure 6 — Boats, Lake 4.

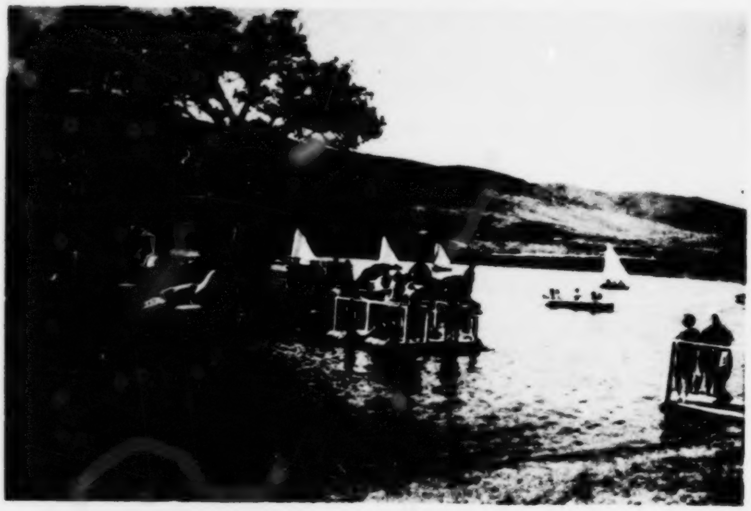

Figure 7 — Ferry to Island, Lake 4.

Lake 4 has two islands, one of which can be reached only by boat and one by a rope connected ferry. This ferry is shown in Figure 7, is very popular with children, and serves to take picnic groups to the island. The wind cooled east shore lines of Lakes 3 and 4 are used daily for small group picnics, and often for parental baby sitting. Areas adjacent to the lakes have been set aside for group activities and include one small playground equipped with swings, slides and other installations. Special group uses include artists who come to paint or sketch, scouting, and in the swim area, group swimming instruction. Lake 5 is designed to provide more islands, a greatly enlarged picnic area as well as the swimming basin shown in Figure 8.

Figure 8 — Swimming area adjacent to Lake 5.

Esthetics

Public acceptance of the Santee recreational lakes is likely based on several factors including esthetics. First time visitors to Santee have come for many reasons. Many, during the period of epidemiological studies were from out-of-state and were most likely relatives of local residents. Records of entry to the swimming area showed many family group visits, again often from beyond the Santee area. Although there was no charge for swimming, these people were more likely motivated by prompting from their local hosts. Acceptance of the lake facility has become, in four years, a matter of extreme local pride.

Another demonstration of the support given the project was the passage by a 4 to 1 majority of a general obligation bond issue of $2,300,000. Of the several factors that have encouraged acceptance of

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the reclaimed water at Santee, the continuous presence of an environment esthetically clean to sight and smell is paramount. Also important is the frequent publicity and reference to the ongoing study by the several supporting agencies which always included the three of health orientation. While full recreational use came gradually, the ever present signs reminding visitors of local health department approval were quite convincing in developing local attitudes and confidence.

Without doubt, a public attitude of approval for water reclamation can be created. A small portion of the public has gradually become aware of waste water reuse at Golden Gate Park in San Francisco(4). Public acceptance of waste water for irrigation and recharge has also been developed in many areas but the social stigma can still act to block reuse in some instances. The importance of the Santee experience is that it was needed, it was successful, and it was accomplished with a concurrent scientific or technical endeavor that was in tune with the current space age era where anything seems possible.

WATER QUALITY

The original objective of the Santee studies (Appendix A2) was to determine the effects of different degrees of sewage treatment on the viral, bacterial, physical and chemical content of waste waters to be used for irrigation, ground water recharge and water contact sports. As the project progressed, emphasis concentrated on water as related to the recreational aspects and utilization of the recreational facility as developed by the Santee County Water District. The study was started, however, under the original plan which called for a series of 2-week samplings as begun in February 1962. The last of the eight quarterly sampling periods terminated in January 1964. This background study produced information regarding hydrology and flow; analyses for bacterial indicators, coliform, fecal coliform and fecal streptococci; the usual sewage quality parameters; and rather detailed chemical analyses of all waters in the study area. The sampling frequency varied from once each 4 hours for some of the bacterial data to once per quarter for some of the chemical analyses. Some proportional samples were obtained from the plant inlet and the primary and secondary effluents.

Samples of water and sewage were collected as shown in Figure 2 and are listed as follows:

1. Raw sewage at plant inlet
2. Primary settled effluent (in overflow channel)
3. Activated sludge effluent (in overflow channel)
4. Oxidation Pond effluent (surface of pond at pump)
5. Oxidation Pond effluent chlorinated (at spreading basin)

5A. Oxidation Pond effluent chlorinated (at Inlet Pond 2)
5B. Outlet Pond 2
6.0. Ground water (Well B) above spreading basin

6.1. Ground water at start of stream 200 feet south of spreading basin

6.2. Ground water in collection ditch 2,500 feet south of spreading basin

7. Inlet water at Lake 4 (collection gallery)

7A. Inlet water chlorinated at Lake 4

7B. Inlet water at Lake 5

7C. Inlet water chlorinated to Swim Area

7D. Outlet water from Swim Area

8. Outlet water at Lake 4

9. Outlet water at Lake 3

Additional ground water samples were occasionally obtained from small wells dug into the aquifer between locations 6.1 and 6.2.

The virus study was started in July 1962 by the San Diego County Department of Public Health with assistance from the California State Water Quality Control Board and the U. S. Public Health Service. Virus samples have generally been obtained by the swab technique with immersion times of 48 to 72 hours, and each sample had a correlating bacterial grab sample. In September 1962, a biological study was added. A regular vector control study involving sampling once or twice per month was carried out by the California Department of Public Health. Summaries of all technical data obtained from these studies are summarized in Appendix B.

Virological Studies

Virological studies on the Santee Water Reclamation Research Project were carried out in the laboratory of the San Diego County Department of Public Health. From July 1962 through June 1964 these studies were supported by the California State Water Quality (Pollution) Control Board. Beginning in July 1964 and continuing through March 1966 the studies were supported by the U. S. Public Health Service. Beginning in May 1965 the studies were specifically directed toward viruses in connection with the trial swimming program as described elsewhere in this report. During all of these studies, J. B. Askew, M. D., Director of Public Health for the County of San Diego, was designated as the Project Director with Mr. R. E. Leach, Chief, Public Health Laboratory, in general charge of the laboratory work. The virus studies were developed and supervised by Mrs. Beatrice England, the Department Virologist. Mrs. Alison Street, Microbiologist, supervised the bacteriological work. As noted in the study plan (see Appendix A2), the principal concern of the health department was the effectiveness of the treatment processes of the system in removal of viruses and bacteria from the sewage, proceeding from its raw state through the individual steps of treatment to its utilization in the recreational facility.

Following installation of the necessary processing equipment in the laboratory, samplings for virus determinations were started on

July 9, 1962. Samples were obtained weekly at the points above listed for both bacteriological and virological determinations. Bacteriological sampling had started on a weekly schedule on March 5, 1962. This arrangement was followed until mid April 1963, following which, virological sampling changed to a biweekly basis. In addition to the regular sampling program carried out at Santee, a sample was obtained on each virus sampling day from the raw sewage flow at the San Diego Treatment Plant. The sampling of the San Diego raw sewage continued until July 8, 1963. This constituted one year of sampling of San Diego sewage for comparison with the first year of sampling of raw sewage at Santee.

Fecal contamination of sewage and reclaimed water is customarily established by biological tests indicating the numbers of organisms per unit of sample. By contrast, virus tests are not screen or indicator tests but are attempts to actually isolate and identify viruses, many of which are known to be pathogenic to humans. Enteroviruses found in sewage generally include over 60 different types belonging to three groups: polio viruses, ECHO viruses, and Coxsackie viruses. Adenoviruses and reoviruses, groups which are clinically considered respiratory, are also recoverable from sewage. Infectious hepatitis is presumed to be present in sewage since water-borne epidemics of infectious hepatitis have been well documented epidemiologically. However, propagation of hepatitis viruses in the laboratory has yet to be confirmed. Since virus particles are present relatively infrequently in comparison with the indicator coliform organisms, a different type of specimen for virus testing must be obtained. During this study, this was accomplished by submerging a swab, consisting of a gauze pad enclosed in a webbing sack, in the flow, for several days. The fluids expressed from these swabs constituted the samples for virologic studies. For virological samplings, the presence of moving water is a necessity since theoretically the swabs suspended in the flow of moving water tend to accumulate by absorption virus particles which are present in the water stream. From the literature it was estimated that 48-72 hours would be adequate submersion time for the swabs.

Following advice received from Dr. Claude Hannoun of the Pasteur Institute of Paris, France, who was a visitor at the Project, a variation on the sampling technique was explored. The Hannoun method of sampling consisted of suspending a swab fabricated from several yards of cheesecloth, which had been cut into ribbons, in a tube approximately three inches in diameter. The liquid from the sampling point was pumped through the tube at a rate calculated to be one gallon per minute for a period of 72 hours. This test was run in parallel with sampling done in the customary manner. The results of virus identifications obtained in the two parallel samples are indicated in Table 4 in the Appendix B. The two sampling points for the test are numbered: "3" for the conventional sampling process and "3a" for the Hannoun process in the activated sludge effluent, and "4" and "4a" in the effluent from the oxidation pond. No significant difference in numbers of isolations resulted from the two methods of sampling of activated sludge effluent. Small numbers of the parallel samples of the oxidation pond effluent failed to give significant results.

The virological sampling swabs were removed from the sewage flow, placed in polyethylene bags, and transmitted to the laboratory in a refrigerated container, arriving at the laboratory within one hour after collection.

Laboratory Methodology — Processing of virus samples in the laboratory was started as soon as possible after arrival of the samples. This consisted of adjustment of pH to approximately pH 8.0 with 1 N sodium hydroxide (phenol red indicator) in an attempt to minimize viral adsorption to the swab. The adjustment of pH was accomplished before removal of the swabs from the plastic bags. The fluid was thoroughly mixed in the bag, then expressed and transferred to flasks to which sufficient normal inactivated chicken serum was added to accomplish a final concentration of 2.5 per cent. Specimens were then either stored at -60°C, or one or both of the two differential centrifugations were performed before storage. The first centrifugation was at 6,000 rpm for 30 minutes to remove bacteria and large particles from the expressed fluid. The supernatant from this centrifugation was centrifugated at 50,000 rpm for two hours to sediment virus. To facilitate adherence of the pellet to the centrifuge tube, sterile gelatin to a final concentration of 0.06 per cent was added just prior to centrifugation. Supernatant fluid from this step was decanted and the pellet was resuspended in one-tenth of the original volume in tissue culture maintenance medium containing antibiotics. Aliquot portions were stored at -60°C until appropriate tissue cultures were available for inoculation.

Until December 1963, each concentrated specimen was inoculated routinely into two tubes of primary African green monkey kidney and two tubes of primary human amnion tissue cultures. After December 1963, testing of a portion of the specimens was modified for the purpose of comparing two different lines of continuous African green monkey tissue cultures (BS-C-1) with primary monkey kidney cultures. In those instances, one primary and one serial culture tube were inoculated rather than two primary cultures of monkey kidney. Selected specimens also were inoculated into two tubes of HeLa tissue culture. From June 25, 1965, to termination of the project, each specimen was inoculated routinely into two tube cultures of primary African green monkey kidney, two tubes of a serial passage line of African green monkey kidney (BS-C-1) and two tubes of primary human amnion culture. (In order to explore the possibility that the unusually steady find of reovirus in samples at Santee could be attributed to the presence of dairy wastes, a series of special samples was processed in the laboratory. Sixteen swab samples were collected, eight representing sewage devoid of dairy wastes and eight from collection points following entrance of dairy wastes into the sewage system. Specimens were inoculated into tube cultures of primary African green monkey kidney and two tube cultures of BS-C-1 serial passage monkey kidney, these cultures being optimum for reovirus isolation. Reovirus was recovered from only four of these sewage samples, two being from each category. Accordingly, from this limited number of tests, no correlation could be made between dairy wastes and reovirus isolations.)

An adsorption period of two hours at 36°C was allowed each inoculated culture. Following this, the inoculum was decanted, the cell layer washed once with Hanks's balanced salt solution, and fresh maintenance medium was added. Cultures were then incubated at 36°C on the revolving tissue culture drum and examined microscopically at one- or two-day intervals for viral cytopathic effect. Specimens showing no cytopathic effect during a two-week observation period were given a second serial passage. Positive culture tubes representing the same specimen were treated individually for virus identification. This was accomplished by neutralization test except for adenovirus. The adenovirus group was identified by the complement-fixation test, and no attempt was made to determine specific adenovirus type. In many instances during the process of identification of a virus, a terminal dilution purification titration was performed. The end point of the titration was assumed to be the point where probably only the predominating virus remained. This generally succeeded in eliminating mixtures of viruses in cultures although occasionally it was necessary either to do an additional terminal dilution purification, or to separate the different viruses by use of specific antisera incorporated in the passage media.

Examination of the records shows that even from four tubes originally inoculated, four or more different viruses per Santee raw sewage sample were occasionally found. Some specimens yielded six virus identifications; one yielded seven. The average was 2.5.

A series of experiments was performed early in the project to study the quantitative effect of the processing procedure upon a known quantity of attenuated polio virus which had been added to simulated Santee samples. It was found that from 36-65 per cent of the virus was lost during the 6,000 rpm centrifugation, as determined by titrations on the supernatant fluids. This loss was presumably due to adsorption and trapping of virus by larger particles. Then centrifugation of a 10 ml aliquot at 50,000 rpm for two hours with resuspension of the pellet in 1 ml theoretically should effect a ten-fold concentration of virus. However, titrations of the concentrated material revealed a range of only 2.5 - 8.5 - fold concentration under varying conditions of pH and added gelatin content. It was possible to recover between 1 and 10 per cent of the virus in the supernatant fluid of the ultra high speed centrifugation. This, in addition to virus loss by adsorption to the centrifuge tube and failure to completely break up and resuspend virus in the pellet, contributed to the less than 10-fold concentration.

In addition to the virus identifications on the liquid samples, attempt was made to recover viruses and bacteria from the intestinal contents of fish taken from the recreational lakes and from samples of algae gathered from the lakes. All such efforts for virus isolation were negative.

In June 1963, a stable line of human embryonic lung tissue culture was received from Dr. Eldon V. Davis of the U. S. Public Health Service station in Phoenix, Arizona. This is the line in which he had recovered a virus from 14 to 22 Indian children during an outbreak of hepatitis on the San Carlos Reservation (5). This tissue culture line was propagated continuously in the County Health Department Laboratory until mid-March 1964. During this nine-month period the human embryonic lung line was inoculated with stool and/or acute phase blood specimens from seven county patients diagnosed as viral hepatitis. No viral agent was recovered as a result of these attempts.

At the present time, no confirmed method has been found for isolation of infectious hepatitis virus. The present study, therefore, does not preclude the presence of this virus in otherwise negative samples.

Results — Appendix B-4 contains a complete record of all virus identifications listed according to the dates of collection of the swab and receipt of the sample in the laboratory. Reference to this Table will indicate that all samples of raw sewage from both San Diego and Santee were positive for virus identification. Mention should be made in this instance that two of the samples showed negative results on the first inoculation but that both of these were positive for reovirus on re-inoculation.

Sampling of primary effluent at Santee was carried out only until June 10, 1963. However, during this period, all samples were positive for virus identifications, with 137 identifications made on the 38 samples, an average of 3.6 per sample. During the 39 month study, 104 samples of raw sewage from Santee yielded 272 identifications of virus, an average of 2.6 identifications per sample. Ninety-four samples of activated sludge effluent obtained by the conventional sampling and the Hannoun process of sampling yielded 192 identifications of virus, an average of 2.0 per sample, with 96 per cent of samples being positive for virus.

Samples of Pond 1 effluent before chlorination numbered 91, with 18 identifications being made on 17 different samples. One sample of the 87 obtained at the entrance to Lake 4 was identified as positive for virus. None of the 66 samples obtained at the outlet of Lake 4 was positive for virus. The one positive sample, Series No. 568, which was obtained from Station 7 at the entrance to Lake 4 was taken on January 18, 1965. Adenovirus was isolated from this sample. An explanation of this possible contamination is the fact that considerable earth work was in progress upstream of the lake and between the lake and the percolation area. The percolate was chlorinated before entering Lake 4, however no sample was taken of the chlorinated percolate on this date. It is assumed that the chlorination was sufficient to remove any virus present.

On May 28, 1965, the sample of percolate before chlorination was positive for adenovirus and reovirus. This sample is number 612 in the Series. This material was chlorinated before entering the trial swimming area, sample number 613, and this determination proved negative for virus. A total of 615 samples processed from both Santee and San Diego yielded 742 isolations of virus.

a. Special Percolation Tests. A project to determine the efficacy of soil percolation of reclaimed water containing known quantities of virus was started in November 1964. This project was occasioned by the fact that it became necessary to establish conditions which would permit percolation through a distance of 400 feet.

The mass oral polio feeding, late in 1962 and early 1963, did not provide such a test because previous work indicated that little or none of the great amount of polio virus, developed in the intestines of vaccinees as a result of this feeding, reached the percolation beds. Therefore test wells were installed in the sand and gravel formation 200 feet and 400 feet downstream from the closest downstream edge of Percolation Bed No. 6, and sampling pumps were located in each well. The wells consisted of perforated six-inch casings approximately 4 feet in length inserted vertically into the formation with the upper end protruding above the surface and capped. The perforations were located so as to sample the upper one or two feet of ground water flow. Following this, approximately 3.17 gallons of attenuated Sabin Polio Type 3 vaccine, supplied by the State Department of Public Health, were proportionately injected into the force main carrying Pond 1 effluent to the percolation beds. The vaccine was titrated in the Virus Laboratory of the San Diego County Department of Public Health before injection and was found to have $10^{7.5}$ $TCID_{50}$ per ml. The rate of injection was adjusted to obtain a calculated titration of $10^{2.9}$ to $10^{3.0}$ $TCID_{50}$ per ml in the suspended vaccine. This was confirmed in the laboratory on samples obtained at intervals of time from the force main discharge. Approximately 140,000 gallons of vaccine suspension was applied to Percolation Bed No. 6. A sample obtained from a swab suspended in the force main discharge over a period of three hours yielded a titration of $10^{2.7}$ $TCID_{50}$ per ml on an unconcentrated eluate. Three unconcentrated grab samples obtained at the same point at one-hour intervals gave titrations of $10^{2.7}$, $10^{3.0}$ and $10^{2.7}$ per ml. An unconcentrated grab sample obtained approximately 72 hours later from the south end of the spreading basin showed a titration of $10^{1.2}$ $TCID_{50}$ per ml. Identification of Polio Type 3 virus was confirmed on each of the samples described above.

Sampling of the test walls was started three and three-quarter hours after application of the vaccine suspension to the percolation basin and was continued at intervals through December and into January. Processing these samples identified Polio 3 virus in all samples obtained from material applied to Percolation Bed No. 6. Following percolation of this suspension of Polio 3 vaccine through 200 feet of sand and gravel, there was no further identification of Polio 3 virus. The same applies to samples collected after 400 feet and 1,500 feet of percolation. The sampling and laboratory processing of these samples were completed over a period of 49 days of test. The conclusion drawn from this test was that percolation of effluent containing attenuated Polio Type 3 virus was effective in removal of the Polio Type 3 virus at distances of 200, 400 and 1,500 feet of subsurface percolation. Later tests indicated that the time of travel of salt solution between Percolation Bed No. 6 and the test wells was less than 48 hours, demonstrating that none of the polio vaccine virus which had been applied to Percolation Bed No. 6 reached the test wells in any instance.

As a result of this test it was decided that transverse subsurface percolation of Pond number 1 effluent across the floor of the valley for a distance of 400 ft. would be adequate for removal of any viruses contained in the stabilization pond effluent which was pumped to the recreation area. The results of the sampling and virological testing are shown in Appendix B-5 of this report. Parenthetically, it should be noted that the samples obtained during this test are not noted in Appendix B-4. The serial numbers, however, do indicate the sequence of the samples and testing in the overall study.

b. Swimming Area Tests. Following nearly three years of operation of the Santee lakes for limited recreational use, which did not include body contact activities, the water district management proposed that an area of the lakes be opened for human contact. It was proposed to construct a special basin in which swimmers could come into contact with the reclaimed water under carefully controlled conditions. This proposal was submitted to the State Department of Public Health. Malcolm H. Merrill, M.D. then Director of the State Department of Public Health, appointed an ad hoc Advisory Committee to analyze the results of the previous two years of study. This committee was composed of James C. MacLaggan, M. D., San Diego Pediatrician and Chairman of the Commission on Public Policy of the California Medical Association; Alexander G. Langmuir, M.D. Chief, Epidemiological Branch, U. S. Public Health Service Communicable Disease Center, Atlanta, Georgia; K. F. Meyer, M.D. Director Emeritus, George Williams Hooper Foundation, University of California Medical Center, San Francisco; A. F. Rasmussen, M.D. Professor and Chairman of the Department of Medical Microbiology and Immunology, University of California at Los Angeles; and Paul F. Wehrle, M.D. Professor of Pediatrics, University of Southern California School of Medicine. This committee met on August 21, 1964, analysed data and reported to Dr. Merrill who issued a statement that the committee had recommended that certain areas of the Santee Development could be opened to broader recreational use on the basis of biological, hydrological, bacteriological and virological information which had been developed. There were, however, two conditions to this recommendation:

1. That the proposed swimming area be developed and maintained in accordance with established standards for artificial pools in California.

2. That the San Diego County Department of Public Health maintain a constant laboratory surveillance and continued evaluation of the recreational program.

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It was also stated that the conclusion to allow swimming was contingent on the maintenance of strict sanitary safeguards, including filtration of the reclaimed water through the ground.

Following the state director's statement of approval, the public health section of the Santee Advisory Committee met and prescribed standards which were to be applied in a testing program to determine the suitability of the reclaimed water for public swimming use. These conditions were as shown in Table 2.

The flow sequence for the swim area test is shown in Figure 5. Samples for virus analysis were collected as noted on pages 25-26.

1. Raw sewage — virus sample (1)
2. Virus sample before chlorination (7B)
3. Virus sample after chlorination (7C)
4. Virus sample at overflow (7D)

To determine that water quality was consistently met to conform to the State standards for quality of water in artificial swimming pools, bacteriological results were accepted as an indication of the quality of the water provided to the swimming area. However, at the same time, samples for virus isolation were collected from the raw sewage at the Santee Project at weekly intervals and bi-weekly from the other locations.

By previous agreement of the Santee Advisory Committee samples following chlorination were to be tested for virus only if a sample obtained the same day from the flow preceding percolation was positive for virus. Samples following chlorination, however, were taken according to the bi-weekly schedule and stored pending the completion of determinations on samples preceding chlorination. Samples of the swimming area outflow were tested for virus at least during each sampling period when swimmers had entered the swimming area. All samples were iced and transported to the laboratory within two hours of collection.

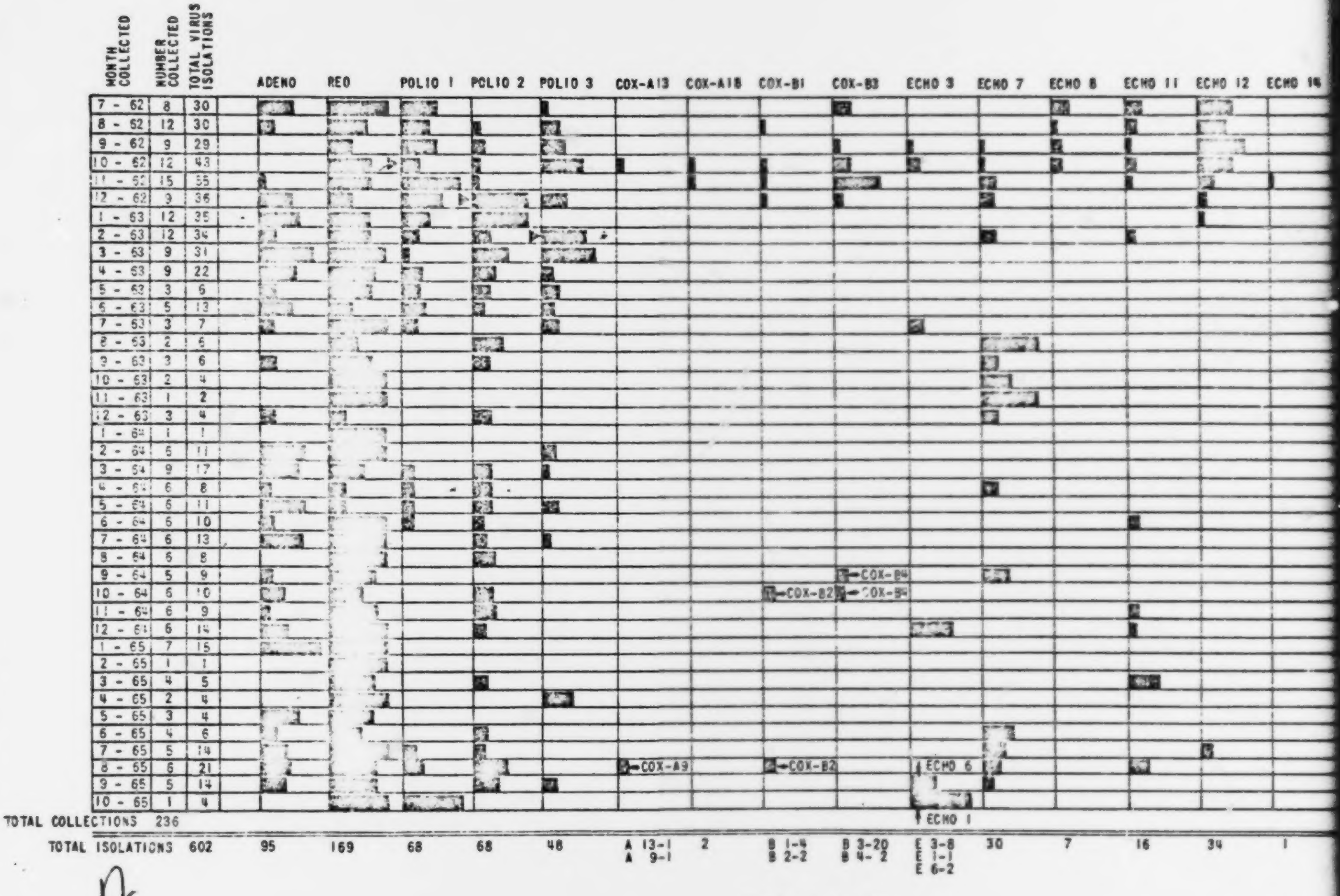
Virus test results are shown in Table 5 as well as in Appendix B-4.

Discussion — Appendix B-6, combines virus results from samples of Santee raw sewage, primary effluent, and activated sludge effluent by month of sample collection, covering the period July 1, 1962 through October 4, 1965. Numbers of specimens positive for each virus are shown. Figure 9 is a presentation of the data from Appendix B-7, with the numbers of specimens positive for each virus converted to per cent of specimens positive for each virus. Although raw sewage was sampled throughout the 39 month period, collection of primary effluent was discontinued after the first 12 months and activated sludge effluent was not collected during the final 6 months of the study nor during four months of 1963. Because of this, it should be pointed out that for comparison of successive years, a bias is introduced by the lack of identical sampling over the entire period. Percentages for the first year are based upon combined results of all three kinds of samples, while percentages for 17 subsequent months reflect only raw sewage and activated sludge specimens, and the final 6 months, plus four months of 1963, are based only upon raw sewage samples. The viral content of primary effluent from the Santee plant did not significantly differ from that of the raw sewage, but the quantity of virus in the activated sludge effluent was markedly reduced as a result of the activated sludge treatment. Therefore, inclusion of primary effluent results during the first year tends to raise the per cent of specimens positive for individual viruses in this tabulation, and inclusion of activated sludge effluent findings has the opposite effect upon the calculated percentages. Despite this, both were included to approach a clearer over-all picture of viruses recovered.

Inasmuch as mass community immunizations with live attenuated Polio virus vaccine were conducted during the first year, the resulting prevalence of the vaccine viruses for a period of months is reflected in these data. The highest incidence of positive specimens for each type of polio extended over the two month period immediately following the mass clinics for the respective type. Polio virus Type 2 isolations were made in moderate numbers throughout the 2½ year period following the mass oral polio vaccine clinics, with fewer recoveries of Polio virus Types 1 and 3. No attempt was made to identify these Polio virus isolates as vaccine or wild virus.

Surveys reported by other investigators(*6, 7, 8, 9, 10*) have demonstrated that enterovirus outbreaks, largely subclinical, occur over limited periods of time, with the responsible etiologic agents varying in different years. For some of the virus types recovered from the Santee specimens over this 39 month period, this trend was substantiated. From July 1962, into January of 1963, ECHO virus Type 12 was isolated repeatedly from Santee sewage and effluents of preliminary treatment, after which it was detected only to the end of the study. ECHO virus Type 8 also was recovered frequently during the summer and fall of 1962 and then disappeared for the remainder of the study period. In contrast, ECHO virus Types 7 and 19 were isolated during each of the four calendar years, 1962-1965. ECHO virus Type 11 was isolated frequently during the summer and fall of 1962, and sporadically during the other three years. ECHO virus Type 20 appeared in the samples only during the summers of 1963 and 1965. ECHO virus Types 1, 6, 14, and 21 were isolated rarely and only during very limited periods of time.

Coxsackie B-1 was isolated only during the period of August through December 1962 with no recoveries throughout the remaining 33 months of the study. Coxsackie B-2 was recovered only twice, once in October of 1964 and once in August of 1965; Coxsackie B-4 was detected only twice, both times in the fall of 1964. A well-defined outbreak of Coxsackie virus B-3 infection in the fall of 1962 reached its peak in the month of November. This is worthy of note not only because Coxsackie outbreaks have been reported to occur generally



MONTH COLLECTED	NUMBER COLLECTED	TOTAL VIRUS ISOLATIONS
7 - 62	8	30
8 - 62	12	30
9 - 62	9	29
10 - 62	12	43
11 - 62	15	55
12 - 62	9	36
1 - 63	12	35
2 - 63	12	34
3 - 63	9	31
4 - 63	9	22
5 - 63	3	6
6 - 63	5	13
7 - 63	3	7
8 - 63	2	6
9 - 63	3	6
10 - 63	2	4
11 - 63	1	2
12 - 63	3	4
1 - 64	1	1
2 - 64	5	11
3 - 64	9	17
4 - 64	6	8
5 - 64	6	11
6 - 64	6	10
7 - 64	6	13
8 - 64	6	8
9 - 64	5	9
10 - 64	6	10
11 - 64	6	9
12 - 64	6	14
1 - 65	7	15
2 - 65	1	1
3 - 65	4	5
4 - 65	2	4
5 - 65	3	4
6 - 65	4	6
7 - 65	5	14
8 - 65	6	21
9 - 65	5	14
10 - 65	1	4

TOTAL COLLECTIONS 236

	ADENO	REO	POLIO 1	POLIO 2	POLIO 3	COX-A13	COX-A18	COX-B1	COX-B3	ECHO 3	ECHO 7	ECHO 8	ECHO 11	ECHO 12	ECHO 14
TOTAL ISOLATIONS 602	95	169	68	68	48	A 13-1 A 9-1	2	B 1-4 B 2-2	B 3-20 B 4- 2	E 3-8 E 1-1 E 6-2	30	7	16	34	1

A

Figure 9 — Virus isolations.

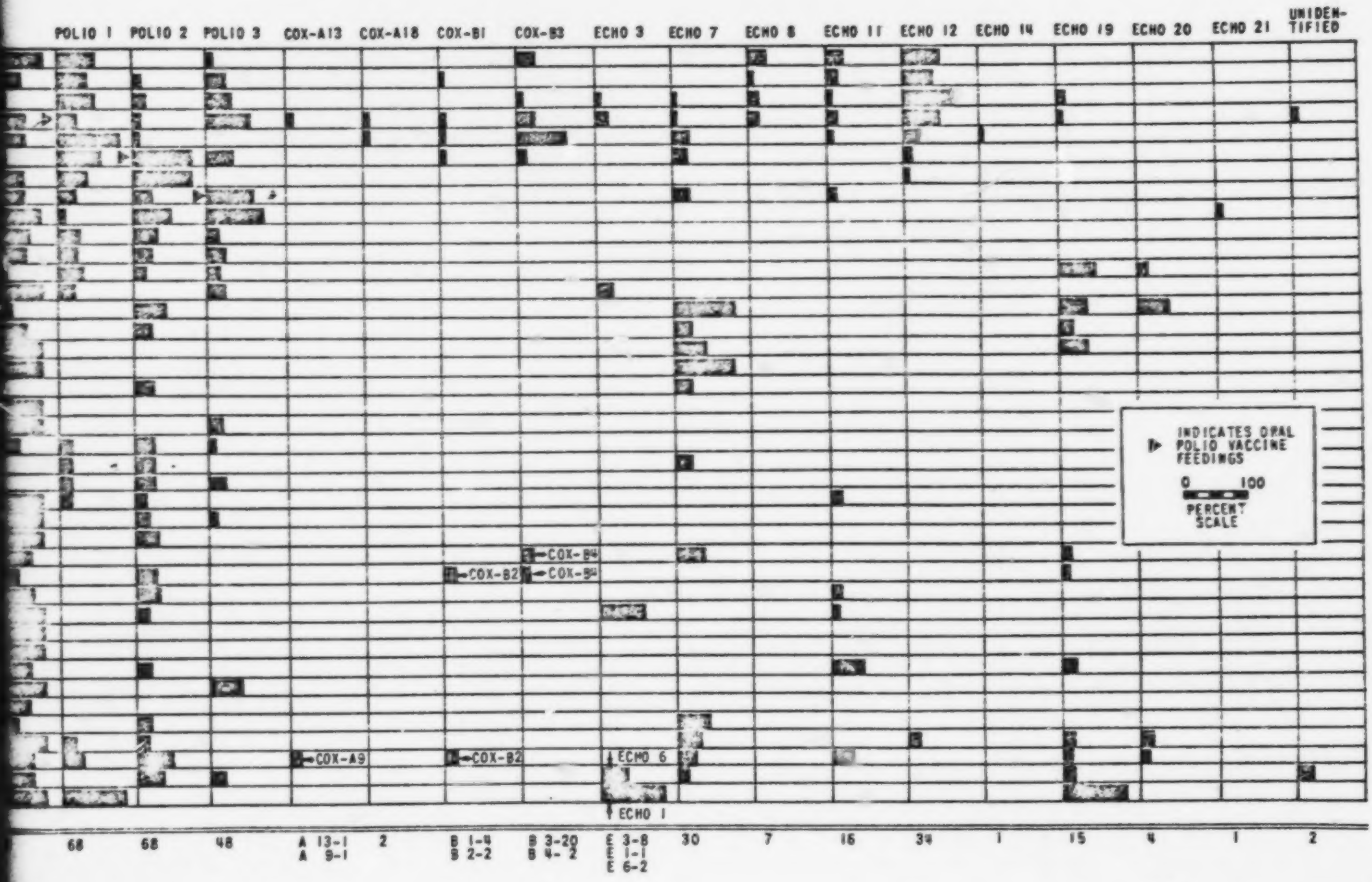


Figure 9 — Virus isolations.

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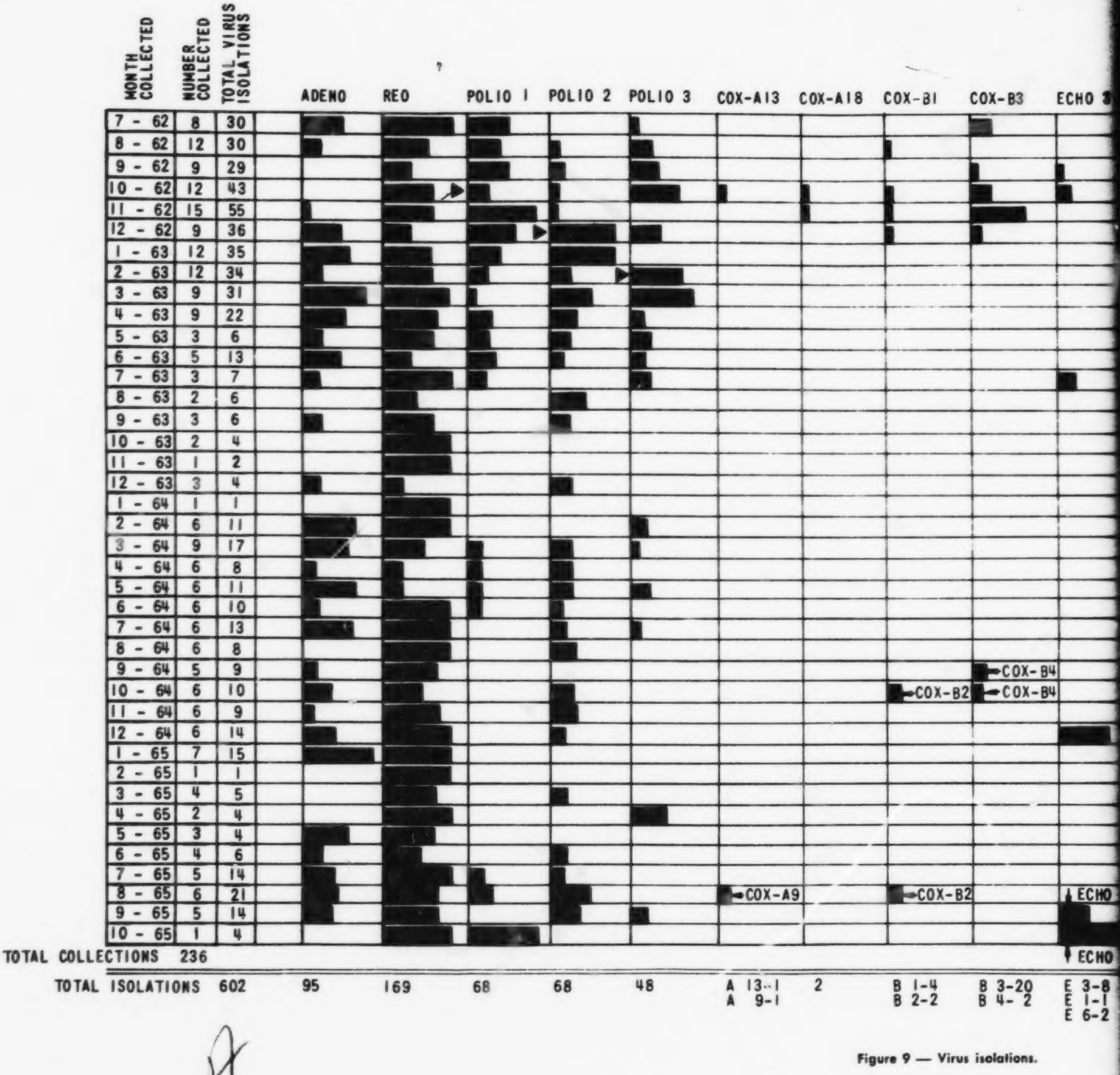
B



MONTH COLLECTED	NUMBER COLLECTED	TOTAL VIRUS ISOLATIONS
7 - 62	8	30
8 - 62	12	30
9 - 62	9	29
10 - 62	12	43
11 - 62	15	55
12 - 62	9	36
1 - 63	12	35
2 - 63	12	34
3 - 63	9	31
4 - 63	9	22
5 - 63	3	6
6 - 63	5	13
7 - 63	3	7
8 - 63	2	6
9 - 63	3	6
10 - 63	2	4
11 - 63	1	2
12 - 63	3	4
1 - 64	1	1
2 - 64	6	11
3 - 64	9	17
4 - 64	6	8
5 - 64	6	11
6 - 64	6	10
7 - 64	6	13
8 - 64	6	8
9 - 64	5	9
10 - 64	6	10
11 - 64	6	9
12 - 64	6	14
1 - 65	7	15
2 - 65	1	1
3 - 65	4	5
4 - 65	2	4
5 - 65	3	4
6 - 65	4	6
7 - 65	5	14
8 - 65	6	21
9 - 65	5	14
10 - 65	1	4

TOTAL COLLECTIONS 236

	ADENO	REO	POLIO 1	POLIO 2	POLIO 3	COX-A13	COX-A18	COX-B1	COX-B3	ECHO 3
TOTAL ISOLATIONS 602	95	169	68	68	48	A 13-1 A 9-1	2	B 1-4 B 2-2	B 3-20 B 4- 2	E 3-8 E 1-1 E 6-2

Figure 9 — Virus isolations.

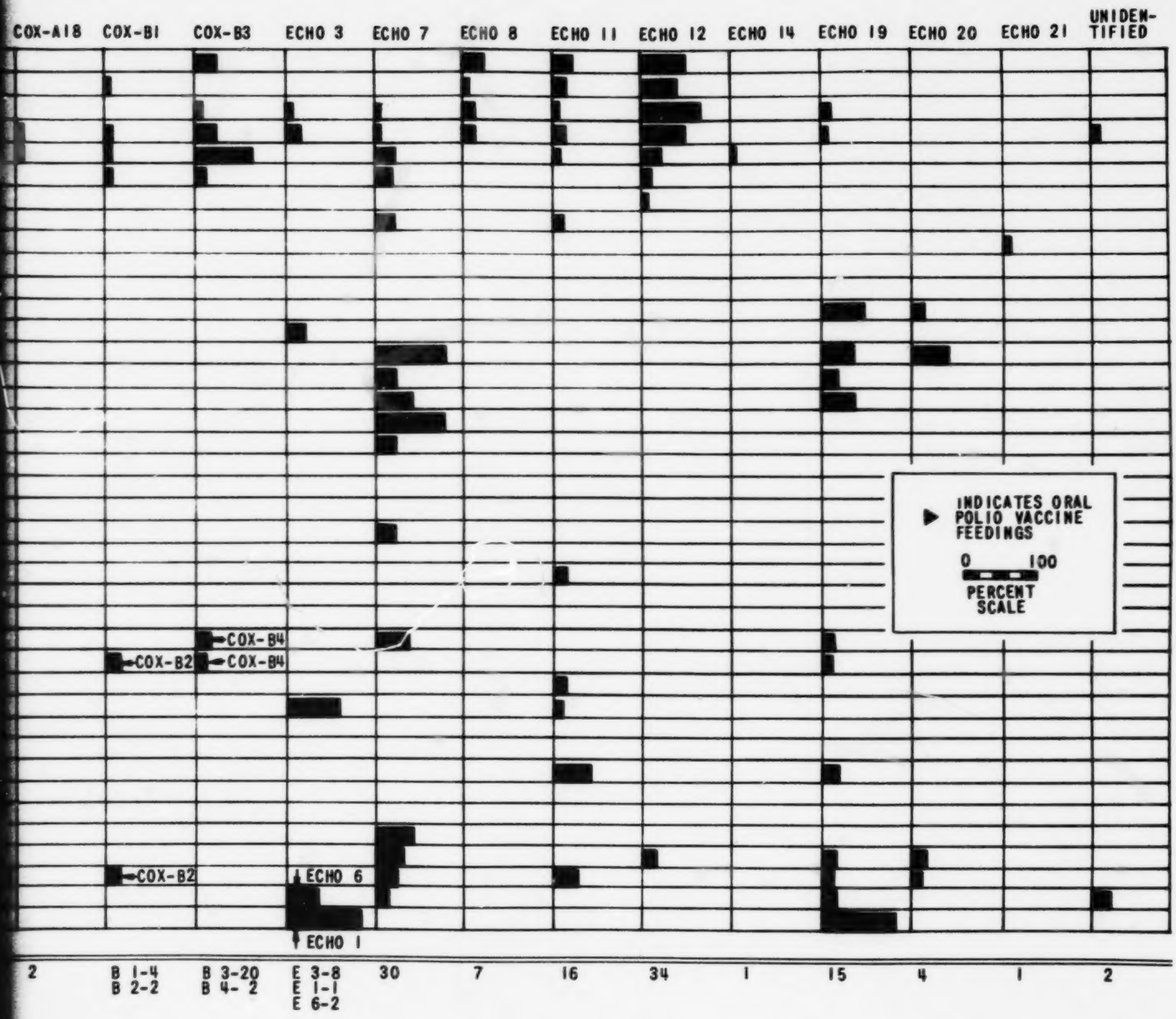


Figure 9 — Virus isolations.

B

during the summer, but also because this outbreak reached its peak concurrently with the peak shedding of oral Polio Type 1 vaccine virus. This is in contrast to reports in the literature (*10, 11*) which indicate that following mass feeding of oral polio vaccine, Polio virus tends to replace other enteroviruses in the sewage. Following the Polio Type 1 vaccine clinics, ECHO virus Type 7 positive specimens also continued to increase, and remained present throughout the period of administration of all three types of polio vaccine.

TABLE 5 — SWIM AREA — SUMMARY OF VIRUS TESTING

Raw Sewage				Swim Area Water											
				Inlet Unchlorinated				Inlet Chlorinated				Outlet			
Samples Coll.	Number Positive	Number Negative	Virus Ident.	Samples Coll.	Number Positive	Number Negative	Virus Ident.	Samples Coll.	Number Positive	Number Negative	Virus Ident.	Samples Coll.	Number Positive	Number Negative	Virus Ident.
Pre-Swimming Period — 10 Days 5/17 - 5/28															
2	2	0	3	4	1	3	2	4 (3 Not Run)	0	1	0	5	0	5	0
25 Swimmer Period — 92 Days 6/1 - 9/1															
15	15	0	41	26	0	26	0	(23 Collected) (Not Run)				18	0	18	0
50 Swimmer Period — 9 Days 9/3 - 9/12															
1	1	0	3	3	0	3	0	(3 Collected) (Not Run)				3	0	3	0
Post-Swimming Period — 9/13 - 10/4															
5	5	0	14	5	0	5	0	(4 Collected) (Not Run)				Not Sampled			
TOTALS															
23	23	0	61	38	1	37	2	34	0	1	0	26	0	26	0

118 Samples Collected—33 Samples Not Run—63 Virus Identifications

The most striking finding was the consistent recovery of Reovirus, which was isolated from specimens of Santee raw sewage or partially treated effluents collected every month of the entire 39 month period. Adenovirus also was frequently recovered throughout the study.

Reports of other workers(*6, 7, 8, 12, 13, 14*) have indicated that in temperate climates there is a seasonal variation in enterovirus infections, with the incidences dropping markedly during the winter months and reaching their peak during late summer or early fall.

The extent to which such infections persist throughout the winter appears to be influenced by climate. At Santee, in 1962, enterovirus outbreaks were reflected in the sewage collected well into the winter. Peak incidence of combined Coxsackie viruses and ECHO viruses was during September, October, and November. There was a complete absence of Coxsackie virus isolations during 1963, but commencing in June of 1963, ECHO viruses were recovered for a period extending into December. ECHO virus Type 7 was prominent from August into December 1963, and ECHO virus Type 19 was frequently found from June through October. The entire year of 1964 yielded a paucity of enteroviruses, with only sporadic isolations of ECHO virus Types 3, 7, 11, and 19, and Coxsackie B-2 and B-4. The greatest number of these isolations occurred in the period September through December. Again in 1965 there were few enterovirus isolations during early spring, but ECHO virus Type 7 was recovered from 7 out of 21 raw sewage samples collected from June to the end of the sampling in early October, and ECHO virus Type 19 from 4 of these samples. In addition, ECHO virus Types 11, 12, and 20 were recovered on one or more occasions during the same period, June into October, 1965.

Seasonal Incidence of Virus Groups in Santee Sewage Specimens:

ECHO viruses: The highest incidence of specimens positive for ECHO viruses occurred during summer and fall in the years of 1962, 1963, and 1965. These peaks were followed by a marked decrease in ECHO virus isolations during the first six months of the calendar years 1963 and 1964. However, the summer of 1964 was devoid of ECHO virus isolations, and the fall of 1964 exhibited only a moderate number. Again the ECHO virus positives declined after the first of the year 1965, then increased markedly during the summer and fall, to the cessation of the study in October 1965.

Adenoviruses: Adenovirus isolations peaked during the early months of 1963 and 1964. However, no comparable increase in positive specimens occurred in early 1965.

Reoviruses: No marked seasonal variation was apparent. However, the consistent finding of positive specimens during every month of the study and the lack of quantitative data may have masked a seasonal variation in *quantity* of virus present. There appeared to be a slight decrease in the number of Reovirus positive specimens in early spring of 1963, 1964, and 1965.

Polioviruses: Use of attenuated live virus vaccines in community clinics in the fall and winter of 1962-63, and an undetermined amount of oral vaccine administration subsequently, precludes assessment of any seasonal incidence of Polio viruses.

Comparison was made of raw sewage from San Diego and Santee in terms of average number of viruses per specimen by month collected and virus type for the period July 1, 1962 through July of 1963, after which time the collection of San Diego raw sewage was discontinued. The limited numbers of specimens involved preclude definitive comparison. However, it is evident that six of the seven ECHO types shown to be circulated in the Santee population during the first 13 months of the virus study were also detected in San Diego raw sewage, and generally during the same season. Coxsackie B-3 was present in both areas in the latter part of 1962, but Coxsackie B-5 only was detected in the San Diego sewage and Coxsackie B-1 only in the Santee sewage. Adenovirus and Reovirus were recovered repeatedly from both areas and the mass feedings of oral polio vaccine were reflected to a comparable extent in the sewage from both communities. The over-all suggestion is that the two communities shared many of the same viruses during this 13-month period. The average number of viruses recovered per sample of raw sewage was 3.6 for San Diego and 3.3 for Santee during this period. This is an insignificant difference.

In addition to the identification of Polio viruses as a routine procedure in this study, the feeding of Sabin Type 1, Type 2, and Type 3 oral polio vaccine on October 21, 1962, December 2, 1962, and February 10, 1963, provided an opportunity for comparison of plaque counts of the three types following their feeding and proceeding through the treatment process.

The plaque technique is one which permits enumeration of infective viral units. A dilute viral suspension is inoculated onto a layer of the susceptible tissue culture cells grown on a flat surface. After a short adsorption period, an overlay of agar containing tissue culture maintenance medium is applied, and the culture is incubated for several days. A vital stain incorporated into the overlay stains the living tissue cells. Counts are made of the discrete colorless macroscopic areas of cellular degeneration (plaques) resulting from viral replication. The result generally is expressed as plaque-forming units per milliliter of inoculum.

Unconcentrated eluates from four stations following each of the three feedings were transmitted to the U.S. Public Health Service, Robert A. Taft Engineering Center, where plaque counts were made on the unconcentrated eluates under the direction of Dr. Norman A. Clarke. These fluids were frozen in dry ice during transmittal. The following table indicates the results of these plaque counts per milliliter:

Date Fed	Sample Date	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent
Type 1 10-21 & 28, 1962	11-1-62	108	276	244	24
Type 2 12-2 & 9, 1962	12-12-62	19	20	25	6
Type 3 2-10-1963	2-18-63	124	166	162	18

It will be noted that little or no reduction in plaque counts resulted from primary treatment but that reductions of 90, 76, and 89 per cent were effected by activated sludge treatment following administration of the three types of oral polio vaccine.

Bacteriological Study

To determine the effectiveness of the various steps of sewage treatment and water reclamation in removal of coliform bacteria, fecal coliforms and fecal streptococci, a bacteriological study was carried out in connection with the virus study on this project. A preliminary period of sampling prior to the coordinated study by the seven cooperating agencies was necessary to insure that the waters in Lake 4 were suitable for boating and accessory use of picnic facilities by the public in the vicinity of Lake 4. This sampling was started in June of 1961 and continued into February 1962, starting time of the cooperative study, with four samples being obtained from various portions of Lake 4 on a regular weekly schedule. Sampling was carried out by personnel of the San Diego County Department of Public Health. These samples were processed in the Laboratory of the County Department of Public Health.

It should be remembered that recreational activities, including boating, picnicking, and "fishing-for-fun" were started in June 1961. All samples obtained during this period, with exception of one set obtained in one of the regular weekly samplings, proved to be satisfactory for recreational waters. The single exception was caused by an inflight of ducks on the Lake 4 which elevated the coliform counts on the samples considerably. Removal of the ducks resulted in lowering the coliform counts to satisfactory levels. Although the recreational lake samples indicated satisfactory bacteriological conditions for human contact, the fact that these waters were of sewage origin was felt to be a deterrent factor to opening the water for direct human contact, although this water had in the treatment process been chlorinated to a very low coliform concentration.

Under the coordinated study as established in January 1962, sampling for coliform bacteria, fecal coliforms and fecal streptococci was started on a weekly basis. This sampling was carried out at the points previously designated and was coordinated with the sampling for virus determinations. Sampling was by the "grab" method with the samples transported to the laboratory immediately after collection in a refrigerated container with samples picked up the same day for virus determinations. During the quarterly studies in which chemical samples were obtained, a mobile laboratory of the California State Department of Public Health was located at the project site. This laboratory made determinations on samples collected at four-hour intervals, around the clock, over a period of one week during each quarter. Appendix B-8 summarizes these results. The results of the laboratory work by the State Department of Public Health correspond generally with samples obtained at weekly intervals throughout the year and which were processed in the County Health Department

Laboratory. This comparison is shown in Table 6. Bacteriological samples were tested for coliform index by the standard methods procedure(*15*); for fecal coli by the confirmatory test done at 45°C(*16*); and for fecal streptococci (*17*), (*18*). For approximately nine months the fecal streptococci tests were done by two methods, the agar plate count and the Millipore filter count. After approximately nine months of comparisons, the Millipore filter was determined to be the better method and was used throughout the remainder of the period of this report. The agar plate count method was discontinued. The results of such analyses are shown by quarterly minima, medians and maxima in Appendix B-9.

Table 6 — COMPARISON OF MEDIANS DETERMINED BY THE SAN DIEGO COUNTY HEALTH DEPARTMENT AND THE CALIFORNIA STATE HEALTH DEPARTMENTS — COLIFORM, FECAL COLIFORM, AND FECAL STREPTOCOCCI IN MPN/100 ml

		Jan. 1962 to Apr. 1963			July 1963 to Jan. 1964		
		Coli	F.C.	F.S.	Coli	F.C.	F.S.
Water before infiltration	SHD*	4.5	<2	2	330,000	130,000	10,200
	CHD	15	2	0	160,000	20,000	3,700
Recovered water — 6.1	SHD				5,200	580	100
	CHD				920	6.8	20
Recovered water — 6.2	SHD				18	<2	<2
	CHD				4.5	<2	0
Lake inlet	SHD	4,900	<180	400	3,300	78	300
	CHD	1,600	49	850	3,300	<180	640
Lake inlet (after chlorination)	SHD				4.5	<2	<2
	CHD				<2	<2	0
Lake 4 outlet	SHD	390	<18	45	200	78	<18
	CHD	170	4	10	170	13	30

		Total record — millions/100 ml (Except F.C.)		
		Coli	F.C.	F.S.
Plant inlet	SHD	49	33%	1.65
	CHD	49	35%	1.3
Primary	SHD	52	33%	1.5
	CHD	49	35%	1.4
Secondary	SHD	15	46%	0.49
	CHD	5.4	44%	0.33
Pond	SHD	0.33	<27%	0.0042
	CHD	0.24	21%	0.0037

*SHD is California State Department of Public Health
CHD is San Diego County Health Department

In the period January 1962 through June 1965 over 3,500 bacteriological determinations were made on these samples. The results for the swimming tests are outlined separately in this report. Additional tests were made for coliforms found in the intestinal content of fish. These showed that concentrations were slightly higher than those in fish obtained from fresh water lakes and water reservoirs, it was felt that this was not believed sufficient to prohibit human consumption of the fish since the bacteria themselves did not reach the edible flesh of the fish. The "fishing-for-fun" program was, therefore, relaxed to permit the taking home of fish caught in Lake 4 and Lake 3.

Results — An interesting aspect of the bacteriological study which was carried out during 13 quarters on most of the stations (a single exception being primary effluent which was sampled only for six quarters) is shown in table 7. It is noted that the primary settling tank was ineffective in removal of coliform bacilli and of fecal streptococci. According to the results, however, which admittedly are biased by unequal numbers of quarters covered, the primary settling process was quite effective in removal of fecal coli. Removals of coliform, fecal coliforms and fecal streptococci by the activated sludge process from material entering this step of the treatment, were relatively uniform, ranging from 80 to 89 per cent removal. Pond 1, the stabilization pond, was also effective in removal of bacteriological content of the activated sludge effluent which entered. Removals of these parameters through Pond 1 ranged between 96 and 99 per cent of those entering Pond 1. In spite of this, the MPN of the coliform bacilli in Pond I effluent was 240,000. The MPN of fecal coliforms was 45,000, and the MPN of fecal streptococci was 3,700, as indicated in the Table. Obviously, this water is unsuitable for human contact without further treatment. Such further treatment was provided in the Santee project by filtration and chlorination before the public was admitted to minimum contact with the reclaimed water.

Although the tabulation of bacteriological results is given by quarters in this report, the detailed weekly analysis results are on record at the County Department of Public Health.

It will be noted from the quarterly record also that waters entering Lake 4, the recreational lake, during the period previous to chlorination at the point of entry (Station 7) contained excessive amounts of coliforms, fecal coliforms and fecal streptococci. In April of 1963, the point of chlorination was changed. Instead of chlorinating at the pick-up point of effluent from Pond 1, the stabilization pond, the reclaimed water was chlorinated at the point of entrance to Lake 4. This Station is designated as 7A, and the effect of chlorination can be readily seen in the table. Comparing the previous record on Station 5, which is the chlorinated effluent from Pond 1 applied to the percolation beds, with the record on Station 7, which is the same water following percolation, it can be seen that additional coliform, fecal coli and fecal streptococci were picked up during the percolation process. This was reason for changing the point of chlorination of the reclaimed water to the entry point into Lake 4, the recreational lake. The effect

Table 7 — REMOVALS OF BACTERIA IN TREATMENT PROCESSES

	Coliform Bacilli			Fecal Coliform			Fecal Streptococci		
	(Calculated from Medians)								
	MPN/ 100 ml	Dif- ference	% Re- moval	MPN/ 100 ml	Dif- ference	% Re- moval	MPN/ 100 ml	Dif- ference	% Re- moval
Raw (13 Qtrs)	49.0 M			23.0 M			1.5 M		
Pr. Eff. (6 Qtrs)	49.0 M	0	0	15.0 M	8 M	35	1.45 M	.05 M	3
A. S. Eff. (13 Qtrs)	5.5 M	43.5 M	89	3.0 M	12.0 M	80	.25 M	1.2 M	83
Pond I Eff. (13 Qtrs)	.24 M	5.26 M	96	.045 M	2.96 M	99	.0037 M	.2463 M	99

M = Millions

of chlorinating the percolated reclaimed water is evident by comparing Station 7 and 7A bacteriological contents. Figure 10 shows the effect of the change in point of chlorination.

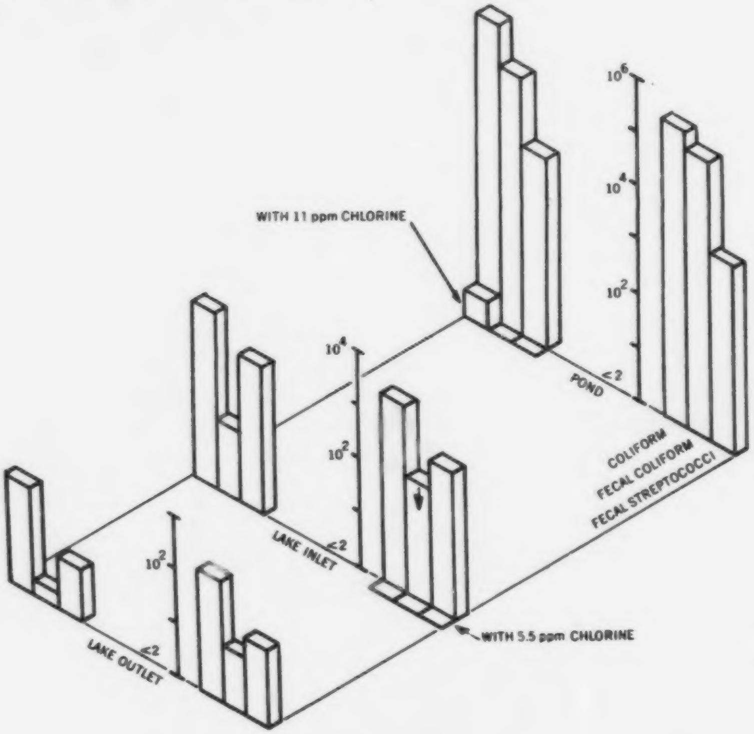


Figure 10 — Effect of chlorination.

Attempts were made to show seasonal peaks in Most Probable Numbers of coliforms, fecal coliform and fecal streptococci. These attempts failed to demonstrate correlation between Most Probable Numbers and Seasons. Seasonal peaks in one year's results, based on quarterly medians, did not ordinarily correspond with seasonal peaks in Most Probable Numbers of these three organisms in succeeding years of the study.

Furthermore, it was not possible to show correlation between the greater numbers of the bacteriological parameters with the higher or lower average isolations of Adenovirus, Reovirus or ECHO viruses per quarter in samples taken simultaneously. Polio virus was omitted from this comparison because of the relatively constant feeding of polio vaccines to the population.

Biological Study

Biological studies at the Santee Reclamation Project were made in an attempt to obtain a working knowledge of the ecology of the Santee lakes. The Santee Reclamation Project area is located in a region described as Californian or California prairie. The hills around the lakes and the canyon floor are covered with weedy annuals, chiefly grasses and scattered clusters of shrubs and broad-leaf evergreens. The canyon floor is relatively densely wooded with sycamore, oak, and thick clumps of chaparral. The combination of a grass land habitat, the availability of water, and the close proximity of human dwellings provides an environment conducive to populations of rodents and aquatic vertebrates. The combination of water and shelter in the canyon has the potential of attracting additional fauna.

A successful fishery initiated in Lakes 3, 4, and 5, demonstrates the ability of the lakes to support producers and consumers. Work on the fisheries aspect has proceeded according to the needs of the study with no regular sampling schedule. A routine vector control study was made for a period of two years.

Phytoplankton — The plankton sampling has included the lakes and also the oxidation pond since it was a treatment device that the study plan considered important in the monitoring program.

The seasonal functioning of the Oxidation Pond has been typified during the winter months by moderate algal activity. Although high numbers (25,000,000/ml)of *Selenastrum* and *Chlorella* were occasionally present, the total biomass was less than 60 ppm. Appendix B 11 shows the record of algae for 1963 and Appendix B 10 shows the total types identified during the study.

In early spring, intermittent blooms of zooplankton have occurred and grazed upon the minute types of algae comprising the standing crop. *Moinodaphnia*, a crustacean, bloomed in February and March of 1964 and 1965. In May 1965, *Brachionus*, a rotifer, reduced the standing crop to the extent that odor problems resulted. After these periods the algal biomass increases.

The peak photosynthetic activity in the pond takes place from June through August. *Oocystis* occurs in greatest abundance during this period. The pond effluent is generally characterized by high ammonia nitrogen (20 mg/liter) and orthophosphate (20 mg/liter PO_4). Alkalinity levels range from 200 to 400 mg/liter. In June through August, the pH rises and ammonia, orthophosphate and alkalinity are reduced. A floc formation of particulate matter consisting of algal cells and adsorbed minerals can be observed settling to the bottom after high activity. During such periods the effluent supplied to the spreading area is of high quality.

Through the months of September and October, the oxidation process is disturbed by Santa Ana conditions, hot eastern desert air masses that flow through the area raising air temperatures as high as 110° and the water to 88°. Subsequent diurnal temperature drops cause a succession of overturns. At such times photosynthetic sulfur bacteria have given the water a milky appearance by utilizing sulfurous bottom waters following the disturbance of overturning. Appendix B 13 shows the chemical and physical record for several sampling periods.

To supplement the oxidation process, and in part to limit overturns, the plant operators have installed a grid type pattern of aeration lines in the deepest portion of the oxidation pond. This system was successful in controlling odor conditions during the fall of 1965.

Inlet waters to Lake 4 contained only 14 genera. Most of those were attached forms of diatoms that had been broken away from the rocks of the streams. No pattern of frequency was apparent. Algal activity in the stream has varied with both flow and weather conditions.

Lake No. 4 has been the prime recreational lake. The waters in this lake always were esthetically acceptable but did develop some undesirable surface scum with the advent of blue-green algae. The lake had the seasonal blooms of diatoms, of green algae, and blue-green algae that are typical of many other lakes. The algae have reflected the variations in the quantity of water supplied to the lake. In 1963 when percolated flows were reduced, the average biomass decreased from range of 5 - 160 ppm to 1 - 20 ppm. The placement of another lake upstream from Lake 4 in April 1965 brought into play the effect that the terraced arrangement of the lakes has on depriving the downstream lakes of nitrate nitrogen at levels of 0.1 mg/liter.

Blue-green algae have become dominant in all the downstream lakes. Growths of blue-green *Anabaena* occurred first in sequence to be followed by *Microcystis*. A Microcystis-Anabaena association may persist throughout the year. Table 8 shows the per cent of blue-green algae during the study period.

Basically the nitrogen content is lower than the phosphorus in the reclaimed water. Green algae utilize much of the available nitrogen along with a lesser proportion of soluble phosphorus in the upstream lakes. Table 8 shows that in Lake 3 during 1963 and 1964 and Lake 4 during 1964 and 1965, the remaining phosphorus has been available for consumption by *Anabaena* species which can then satisfy their nitrogen requirement by fixation of atmospheric nitrogen(*19, 21, 25*).

The nitrogen content of blue-green algae is high in comparison with green algae,(*23*). Organic nitrogen in the lakes has reached the unusually high levels of 6-7 mg/liter when blue-green algae were present. Appendix B 13 shows this relation in Lake 4 for 1965.

Some of this algal biomass is eventually tied up in the food chain, but most of it ends up on the bottom sediments as a flocculent partially decomposed mass. Phosphate is more readily liberated than is nitrogen in an immediately usable form during the decomposition and consumption of the biomass (*20, 22*). Phosphate consequently returns to the life cycle at a faster rate compounding the inverse nitrogen phosphorus ratio in the photosynthetic zone, and contributing again to the productivity of the blue-green biomass.

The blue-green algal problem at the Santee Lakes has been important in its effect on both the beauty of the Lakes and the fishery. The downstream lakes 2, 3, and 4 are now in advanced states of eutrophication. The bottom sediments have accumulated so rapidly that the lakes can now be depleted of oxygen during certain periods, as demonstrated by the 1965 fish kills.

Table 8 — QUARTERLY AVERAGE OF NITROGEN AND PHOSPHORUS AS mg/liter

		Lake No. 4 Inlet		Lake No. 4				
	Quarter	Inorganic Nitrogen (N)	Inorganic Phosphorus (PO_4)	Inorganic Nitrogen (N)	Inorganic Phosphorus (PO_4)	Organic Nitrogen (N)	Organic Phosphorus (PO_4)	% Anabaena
1963	3	0.52	0.56	0.17	0.57	0.92	1.30	0
	4	0.65	0.92	0.37	0.46	1.53	0.96	10
1964	1	0.63	0.30	0.08	0.0	1.20	0.44	0
	2	0.36	1.11	0.07	0.76	1.00	1.10	0
	3	0.77	0.06	0.13	0.0	1.20	0.24	5
	4	0.33	0.05	0.08	0.02	0.80	0.26	0
1965	1	2.30	9.50	0.19	1.40	1.20	0.20	0
	2	0.56	2.60	0.20	1.20	1.60	0.54	0
	3	0.0	2.30	0.20	0.70	5.40	1.80	90
				Lake No. 3				
[illegible]	3			0.24	0.10	1.80	1.04	30
	4			0.07	0.25	0.07	1.08	0
[illegible]	1			0.03	0.0	1.30	0.26	10
	2			0.12	0.0	4.00	0.58	50
	3			0.08	0.01	3.40	0.32	80
	4			0.13	0.03	1.70	0.26	5

Floating mats of filamentous growths of *Cladophora* occur in the shallow water and have to be removed to prevent nuisance conditions.

Rooted aquatic plants have appeared at one time or another in all of the lakes. Three of the most common were: *Potomogeton; Najas;*

and *Typha*. All except *Typha* have generally been restricted in growth by the turbidity of the lakes. Growths of *Typha*, cattails, are periodically removed by hand.

Benthic Organisms — Benthic organisms are beneficial in that they break down organic material in the Oxidation Pond and form part of the food chain in the recreational lakes. They can, in turn, become a nuisance, especially in the enriched environment of oxidation ponds, because of the lack of predators. The only limitations to benthic types in the Oxidation Pond are occasional depressed oxygen conditions and some of the inhibiting effects of the decaying organic material. Benthic organisms could reduce the recreational use of the lakes when they create nuisance after emergence. Some benthics can become vectors for disease and these require control. The Vector control at Santee has included some organisms other than the benthonic ones. The control of mosquitoes at the Santee lakes and in the other waterways of the project has been practiced continuously since the start of the project utilizing both mosquito fish and the pesticides Malathion and Baytex.

In July 1962, a vector control study was started by the State Department of Public Health. Its purpose was to determine the numbers, species, and variations of benthic organisms and to develop control recommendations. A routine sampling program was established on an alternate week basis covering all lakes and waterways in the project. The data obtained in the Vector Control Study are enumerated in Appendix B 16. Of primary importance are the Tendipedidae, a form of aquatic midge which is a major pest in California. Precise counts of this midge were taken both at sampling stations in the lakes and in light traps near the lakes. Twelve species of Tendipedidae have been collected in the lakes and waterways and 17 species have been found in light traps.

In a follow-up survey by the Bureau of Vector Control in November 1965 the larval midge populations appeared to be within the range of variations experienced in the same month in 1962 and 1963, except in the channel below the spreading basin which exceeded the range. Lake 5, a new lake, hasn't yet developed the population levels typical of the other lakes.

Small numbers of Physa, Heliidae larvae and Odonata were found in most waterways. Midges were more numerous in the channel arising from the spreading basin water and leaving the project. Fortunately, the proximity of homes in that area is such that the fly-off of midges has not created a major public nuisance. Along with the Sycamore Creek discharge from the project, Ponds #1 and #2 were the most productive source of the midges. The fish and other predators greatly restricted the numbers of midges that have developed in Lakes 3 and 4. The midges are also reduced in numbers with the higher summer temperatures and there is some indication that their abundance is directly related also to oxygen levels.

Mosquito larvae that have been identified include *Culex pipiens, C. peus, C. tarsalis, Culiseta inornata* and *Anopheles franciscanus*. The mosquitos problem has been the most serious when vegetation grows up along the banks. They are especially troublesome in the effluent areas of Pond #1, since mosquito fish cannot be used in this environment. Seepage pools within the area of the proposed Lake #5 and adjacent to or in the bottom of the spreading area have also frequently contained mosquito larvae. Fish life has limited the development of mosquitoes in Lakes #3 and #4 and other control procedures have kept the shoreline areas clean. For the two and one-half years to the end of 1963, records show that more than 1300 gallons of larvicide have been used in the project. Approximately 10% of the spraying effort has involved the percolation area and the stream above the recreational lakes. No spraying has been necessary in the recreation lakes. The concentration of residual Malathion or Baytex from the use of this 2% larvicide solution that could be expected to have entered the recreational lake is approximately one part per billion.

Over-all productivity in Lake 4 was further measured by sampling 13 stations as noted in Appendix B 14. In general, the shallow water stations tended to have higher populations. Predominate forms present were the Tendiped larvae. The snails and annelids were, for the most part, shallow water inhabitants, while phantom midges were most numerous in the deeper waters. Other bottom forms — mayflies and dragonflies — were never abundant.

The Fishery — Test seining was conducted during 1962 and 1963. The catch composition is plotted in Appendix B 17. The seining also developed information about growth of fishes, distribution of fishes among the lakes, evidence of reproduction, and an estimate of the standing crop. Length frequency data are shown in Appendix B 17. Growth of the redear sunfish in Lake 3 was limited in size from October 1962 to August 1963. The median size shifted by only 0.2 inch. The median size of the redear sunfish was about 4.8 inches. In Lake 4 the modal length for redear increased 0.6 inch from 1962 to 1963. The median size in Lake 3 has been consistently larger than in Lake 4. Crowding and competition for food are considered responsible for the smaller size of the redear in Lake 4. The threadfin shad in Lake 3 show a considerable growth rate, but this is probably related to selective mortality during the December 1962 fish kill. As shown in Appendix B 17, this kill greatly decreased the population. The length frequency data for threadfin shad in Lake 4 also show an increase in modal size and a decrease in relative numbers.

The bass have done well in both lakes with increases in size and numbers being noted in the catches and in subsequent seinings. An estimate was made of the standing crop of fish in Lake 4 from seining procedures in which approximately an acre area of the lake was seined with a 400-foot net. The calculated yield was about 400 pounds per acre. It should be noted, however, that this crop is due to a large number of small panfish and threadfin shad, with relatively few predator fish.

The fishing program has been unsuccessful as far as a balanced sport fishing program is concerned. It has been necessary to plant additional numbers of bass in both ponds in order to improve the predator ratio. Some panfish were also removed for stocking in other waters.

Lake 2 was drained and refilled with reclaimed water in February 1965; 1,120 male *Tilapia* hybrids were planted in the lake as an experimental warmwater research project, by the California Department of Fish and Game June 7, 1965. The project, however, was abruptly terminated by the general fishkill which affected all of the lakes on September 8, 1965. Ninety-one Tilapia were collected and measured after the kill. The mean total length was 6.6 inches. At the time of stocking the mean total length was under 1.5 inches.

A major fishkill occurred in December of 1962 in Lake 3; an estimated 10,000 shad died. No other species of fish died. Sharp diurnal temperature drops below the range of tolerance for the shad was the probable cause. Shad cannot withstand temperatures much below 50°F(*24*). Appendix B 13 illustrates the typical annual temperature cycle of the lakes. Minor kills of shad have been observed periodically in Lakes 3 and 4 during the winter months of December and January.

Major fishkills occurred again in August and September of 1965. During August 9 through 11, Lake 4 was primarily affected. The kill of an estimated 40,000 fish was selective for shad, sunfish and some small bass. Dissolved oxygen dropped to less than 1 ppm by each morning. A series of very hot days preceded the kill with water temperature as high as 84°F. The low dissolved oxygen and consequent fishkill resulted from the diurnal respiration of the dominating growth of *Anabaena*.

From September 6 through 10, another kill occurred simultaneously in all the lakes; approximately 10,000 dead fish were removed from Lake 4, 10,000 from Lake 3, and 150 *Tilapia* from Lake 2. Large 5 pound bass and catfish were among those collected.

As in August, hot weather preceded the kill, but sudden cool weather beginning September 6 induced overnight turnovers in the lakes. The apparent oxygen demand was so great that Lake 4 remained totally anaerobic for three days. A fishy, sulfurous odor permeated the area, and the water became clear. The *Anabaena* that had been abundant a few days earlier disappeared.

The anaerobic conditions in Lakes 3 and 2 were not as severe, and recovery was more rapid. Both of these lakes had biomass consisting of blue-green algae, *Microcystis* and *Anabaena*, in such abundance that algal scums extended over their entire surfaces.

The kills did not eliminate all the fish. Some survived by coming to the surface and, in Lake 4, the inlet flow provided a limited zone of refuge. Some small catches are still reported by fishermen.

The Santee Lakes have been continuously supplied with good quality water reclaimed from sewage. Sewage contains a broad spectrum of nutrients. The reclaimed waters retained a sufficient amount of this fertility to support a highly productive fishery. However, the continuous enrichment of a chain of lakes which function essentially as nutrient traps has shortened the duration of their reliability. Well over half of the nutrient input is retained in Lake 4 in some form or another as shown in Table 9.

Enrichment has resulted in large blooms of algae dominated by a few types of green algae and subsequently by blue-green algae. The over-production of algae has created problems ranging from algal scums to oxygen depressions.

Part of the price of this enrichment has already been paid through devastating fishkills. The answer lies in finding feasible means to correct and control the conditions of eutrophication.

Table 9 — CALCULATED NUTRIENT SUMMARY, 1962 - 1965

	Total Nitrogen (N)	Total Phosphorus (P)
Lake 4		
	Pounds	Pounds
Inflow	11,000	2,970
Outflow	4,580	1,240
Percolation	290	270
Fish Removed (Inc. Kill)	280	27
Algal Crop (Inc. detritus)	200	50
Fish crop	20	2
Unaccounted	5,630	1,371
Lake 3		
Inflow	4,580	1,240
Outflow	2,500	500
Percolation	250	270
Fish removed	190	27
Algal crop (Inc. detritus)	300	70
Fish crop	20	2
Unaccounted	1,320	371

Note: The above table was calculated from flows, determinations of N and P in filtered and unfiltered water samples and fish seining and catch records. N and P for fish were calculated by using 2.0% N and 0.2% P, (based wet weight).

Chemistry Study

As can be judged from the biology study, the nutrient contents have been of primary importance in the overall chemical quality of water at Santee. The amounts of ammonia nitrogen have also been important in their effect on the chlorination process prior to the waters' recreational use.

Suspended solids in the activated sludge process were limited to 6,000 mg/liter for best operation. This level could at times carry over appreciable solids as indicated by the range (23-315 mg/liter) of suspended solids for the secondary effluent. Appendix B 18.

The Oxidation Pond effluent also shows a considerable range (17-173 mg/liter) of suspended solids, reflecting the variations in plankton growths. Some variation in suspended-solids concentrations in the raw, primary, and activated sludge was caused by the 15 to 20 percent return flow from the Oxidation Pond to the plant inlet. Suspended solids reduction in the conventional treatment plant averaged 89 per cent.

An estimated 500 cubic feet of nonvolatile suspended solids were pumped to the spreading basins through 1965. This material would fill a small per cent of the voids in the top 6 inches of infiltration area surface soil and has likely added to the need for routine quarterly surface scarification. The long time effects of these solids as well as the precipitated inorganic salts could not be determined during the limited study period.

During the eight quarterly samplings, 5-day BOD measurements were made at each of the four stages of the treatment process. These measurements as summarized in Table 10 depict ranges and averages through the treatment process. Average BOD concentrations are shown to vary from about 300 mg/liter in the raw sewage to 3.5 mg/-liter at the inlet to Lake 4. At the flow of 0.9 mgd the secondary treatment process showed a capability for removal of 91 percent of the BOD. The average BOD for the pond effluent showed a small increase over the influent. Overall BOD removals through the percolation area were approximately 99 percent. The highest concentrations of BOD found in raw sewage were due to the operating difficulties with sludge pumping. Five sets of composite samples on the raw, primary, and secondary effluent were also examined and these results showed 88 per cent BOD removal for secondary treatment.

Of significance are the small BOD concentrations found at sample point 6.1, which is only 200 feet below the percolation area. The average 3.5 mg/liter measured at this point indicates very good removal in the percolation process. The BOD of the inlet waters of Lake 4 would not be an indication of the water source.

Average COD results are also shown in Table 10 along with ranges. Occasional high readings from the grab samples obtained from either the raw sewage or the primary effluent caused large variations from the averages. Inconsistent COD removals through the primary treatment could also be related to the poor primary quality. Average concentrations at all other sampling points appeared to be consistent and showed overall removals of about 95 percent after percolation and 80 percent after secondary treatment. The Oxidation Pond waters showed a slight buildup from the average concentrations found after activated sludge treatment. This was especially true when supernatant was discharged directly to the pond.

Table 10 — FIVE-DAY BOD AND COD, mg/liter

Location	BOD		COD		Composite	
	Range	Avg	Range	Avg	BOD	COD
Plant inlet	164 to 630	301	256 to 1,930	1,090	268	1,020
Primary effluent	125 to 575	278	257 to 2,000	772	212	572
Secondary effluent	14 to 120	25	104 to 252	175	38	185
Pond effluent	16 to 60	29	55 to 328	185		
Ground water 6.0	1 to 8	1.5	0 to 77	24		
Ground water 6.1	1 to 9.1	4.4	29 to 60	46		
Ground water 6.2	1 to 6.4	2.1	0 to 32	19		
Lake 4 inlet	1 to 8	3.5	19 to 68	41		
Lake 4 outlet	3 to 10	6.0	24 to 112	52		

The percolation area provided an average 78 percent removal of the COD carried in the Oxidation Pond effluent. Chlorination of the pond waters reduced the COD by 10 mg/liter. The two sample points, 6.1 and 6.2, showed COD concentrations that varied with time. Early in the study, COD concentrations at 6.2 showed the dilution effects of rainfall. Later, as all the water in the underground basin became reclaimed water, COD concentrations at 6.1 and 6.2 became more nearly equal. The COD concentration in the final waters entering the Lakes has been one of the characteristics that could identify the source of the reclaimed water.

A conductivity record of plant influent and Lake 4 influent was obtained during February 1962. In May 1962 a record of the plant inlet conductivity was again obtained. These readings showed conductivity changes from an average of 1,500 micromhos to as high as 2,000 micromhos for an occasional 1 hour period following softener backwash operations. Conductivity readings for the Lake 4 inlet were very consistent at levels of 1,300 micromhos and showed some change with the arrival of runoff in mid-February. Measurements of total dissolved solids by evaporation correlated well with conductivity and have been summarized in Appendix B-18. Individual station variations among quarterly sampling periods can be explained by entry of runoff or by concentration of salts through evaporation. Dissolved solids reduction through the percolation process resulted from some dilution with natural ground water and some precipitation of calcium salts. This reduction decreased with time. The dissolved solids in the potable water averaged 750 mg/liter.

Measurements of alkalinity and pH are also shown in Appendix B-18. Measurements in February were made in the field. All others were made in the laboratory. The Oxidation Pond and Lake 4 showed increased pH readings due to algae growths for all quarterly periods. Alkalinity removal occurred in both the pond and percolation process. Alkalinity removal in the pond was seasonally dependent on photosynthesis. The potable water delivered at Santee had a pH range of 7.5 to 8.5 and an alkalinity of about 120 mg/liter.

Complete chemical analyses of waters at several stages in the reclamation process were obtained for each quarterly period. Composites were used for stations 1, 2, and 3. Results of these analyses, except for boron, fluoride, and silica, have been plotted as milliequivalents per liter (meq/liter) in Figures 11 and 12. The loss of ammonia, potassium and calcium through the process is apparent. Calcium is removed as calcium carbonate or phosphate in the Oxidation Pond, the lakes, and the percolation area. Figure 12 also shows reductions taking place for bicarbonate alkalinity and sulfate. Loss of alkalinity can be attributed to the above precipitation as calcium carbonate. The sulfate reduction in the percolation area appeared to end during the second year and was probably the result of ion exchange. The concentrating effects of evaporation in the lakes were emphasized in August by changes in the sodium and chloride ions. The sodium and chloride ions showed similar stability at the various treatment stages except for a small loss of sodium after percolation that was apparent during the first year. This could be attributed to ion exchange in the calcium-type soils. Results from the Lake 4 inlet sampling point in November indicated that this soil capacity for exchange of sodium was exhausted. Potassium and ammonia also shown in Figure 11 reached their minimum concentrations after the percolation process.

Fluoride and nitrate did not greatly affect ion balances since the maximum concentration for each was only about 2 mg/liter. The fluoride in Lake 4 was at the potable water concentration of 0.4 mg/liter. Measurements of boron showed peak readings of about 1.0 milligram per liter and final readings of 0.6 to 0.8 mg/liter in Lake 4. Silica concentrations varied between 16 and 30 mg/liter for all stages in the reclamation process with little change from the 19 to 28 mg/liter found in the raw sewage.

The nitrogen cycle including nitrates, ammonia, and organic nitrogen is plotted by range of quarterly averages in Figure 13. Nitrite nitrogen was significant only at the entrance to Lake 4 where it was occasionally more than 0.1 mg/liter. Effective treatment for removal of organic nitrogen has taken place in the activated sludge and infiltration processes. The ammonia nitrogen conversion was accomplished in the pond, in the spreading area, and in the stream. Analyses of water at location 6.1 showed a range of 0.32 to 14 mg/liter for ammonia nitrogen. The low readings at location 6.1 coincided with low flows to the spreading area in April 1963. The high reading for ammonia nitrogen at location 6.1 was always reduced by stream conditions so that Lake 4 inlet waters never exceeded 1.5 mg/liter.

Nitrate nitrogen was built up in the spreading operation and occasionally to larger concentrations in the stream after the spreading

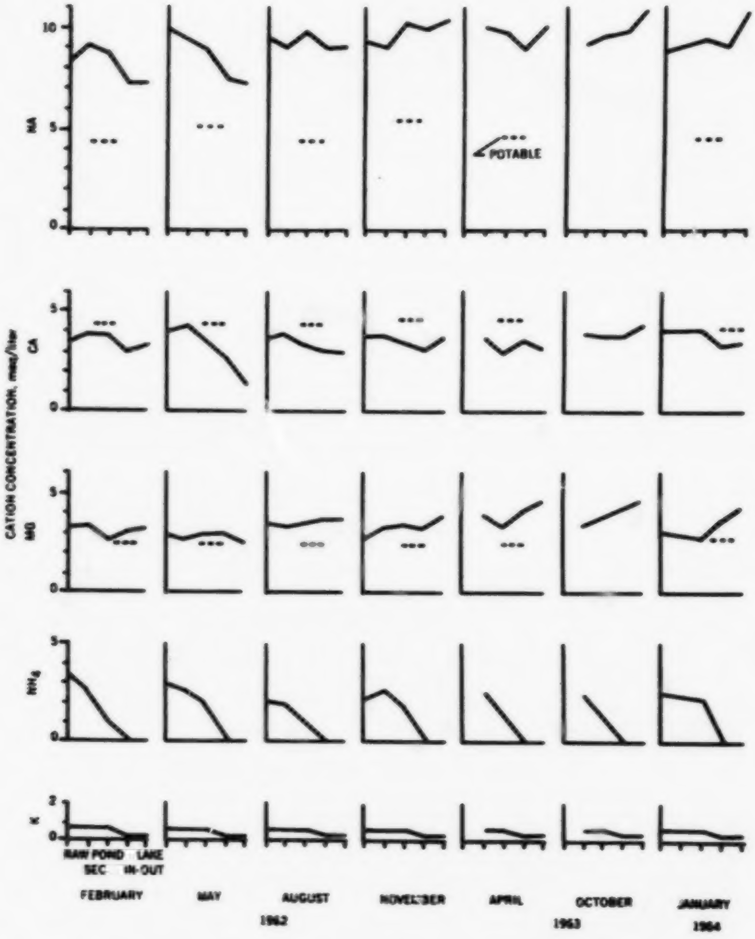


Figure 11 — Quarterly range of cation concentrations.

operation. The water coming from the ground at location 6.1 also generally had a larger nitrate concentration than waters at location 6.2 did. Nitrate nitrogen was measured as high as 2.1 mg/liter at the entrance to the lake. Total nitrogen was reduced from an average of 60 to about 2 mg/liter at the inlet to the lake. Removal of nitrogen in the stream has been as high as 15 pounds per day.

During 1965 nitrogen removals in the stream system decreased due to increased excavation activities. The stream as a treatment unit has not been effective since the filling of Lake 5. Total nitrogen

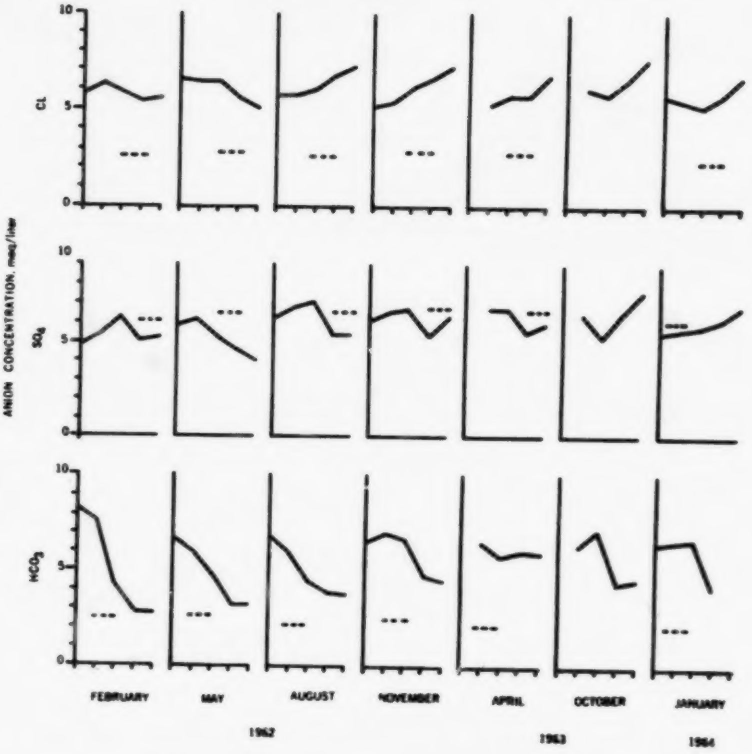


Figure 12 — Quarterly range of anion concentrations.

reaching Lake 5 has averaged 8 mg/liter and ammonium nitrogen about 7 mg/liter or about the same as the waters immediately below the percolation beds. Phosphorus as measured in concentrations of phosphate (PO_4) entering Lake 5 in 1965 has also reflected the changes and has been equal to total nitrogen concentrations. A summary of soluble and total phosphate analyses is shown in Table 11 and the range through the treatment process is depicted in Figure 14. Again it is significant that concentrations of phosphate reaching the inlet to Lake 4 showed average residuals of 1.5 mg/liter of orthophosphate in spite of concentrations of 10 to 12 mg/liter breaking through the infiltration area at sample location 6.1. The reduction in phosphate was greatest in the activated sludge process, but wide variability existed in the process. The average concentration of phosphate in the Oxidation Pond averaged 24 mg/liter, which equalled the average found in the activated sludge effluent. Measurements of phosphate in both filtered and unfiltered samples were made in August and November 1962. These analyses showed that total phosphate equaled 125 percent of soluble phosphate for the activated sludge and pond effluent samples. Total phosphate averaged 1.3 milligrams per liter for waters leaving Lake 4 and was 150 percent of the orthophosphate measurement.

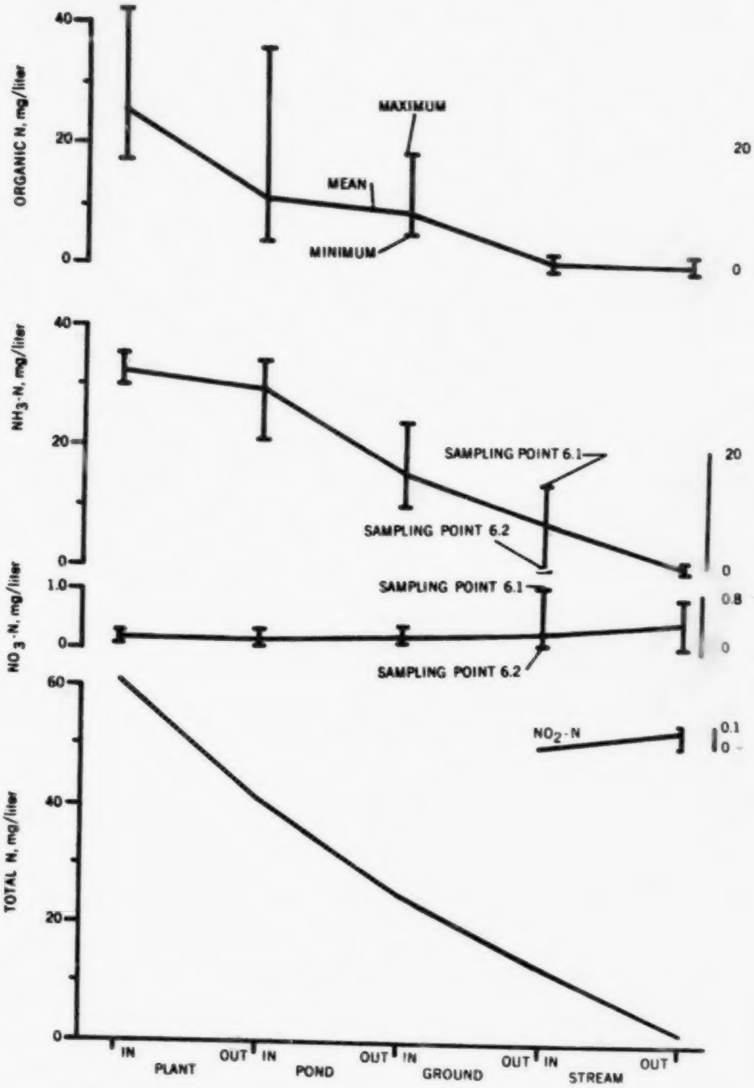


Figure 13 — Summary of nitrogen averages, range of quarterly values.

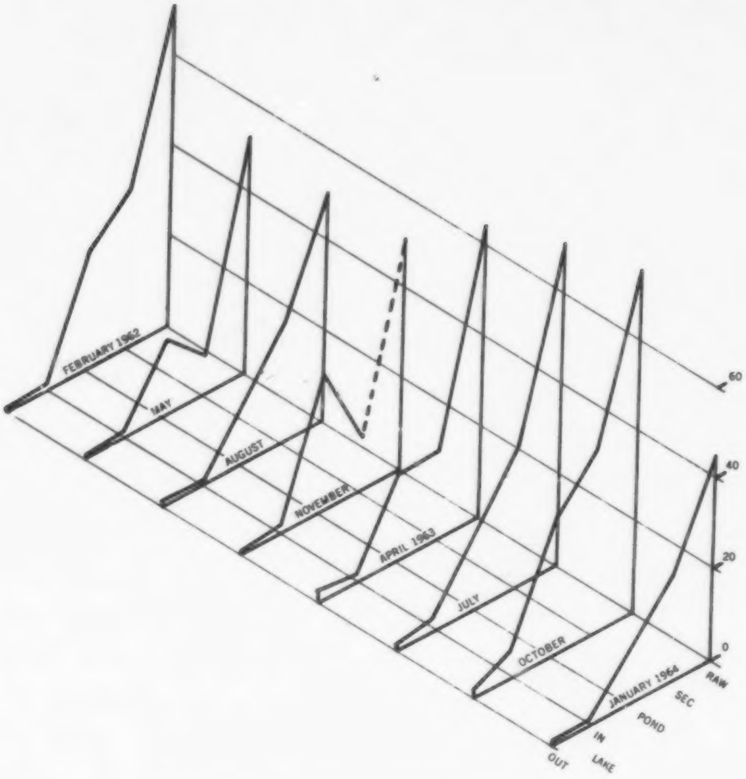


Figure 14 — Soluble phosphate as PO_4 in mg/liter.

The results of measurements of synthetic detergents, apparent ABS, are tabulated in Table 12. Synthetic detergents have been controlled primarily by the activated sludge process, which averaged about 50 percent removal. The pond and percolation processes have removed, on the average, an additional 30 percent. Concentrations of ABS in samples obtained in November in the stream below the percolation area (location 6.1) gradually increased until they equaled those obtained as in the water being percolated. During the second year, after a period of no percolation, some improvement was noted. Waters obtained at sample location 6.1 showed concentrations that have gradually increased to about 30 per cent of the ABS percolated. Some ABS destruction probably occurred at the lower spreading rates. The changeover in production to biodegradable detergents reduced the synthetic detergent residuals to about 1 mg/liter in the Oxidation Pond.

Table 11 — SOLUBLE AND TOTAL PHOSPHATES AS PO_4 IN mg/liter

Location	Soluble (filtered) Range	Soluble (filtered) Avg	Total[a] (unfiltered) Range	Total[a] (unfiltered) Avg
Plant inlet	36 to 96	61		
Primary effluent	39 to 90	60		
Secondary effluent	3.0 to 55	24	8.8 to 45	25
Pond effluent	11 to 41	24	19 to 41	30
Ground water 6.0	0.0 to 4.2	0.5		
Ground water 6.1	0.15 to 22	12		
Ground water 6.2	0.0 to 1.3			
Lake 4 inlet	0.0 to 15	1.5	1.1 to 5.0	2.0
Lake 4 outlet	0.0 to 2.2	0.82	0.[illegible]8 to 4.5	1.3
Lake 3 outlet	0.3 to 0.68	0.40[a]		

[a] Record of two quarterly periods only (August and November 1962).

Measurements of phenol at all stations during the February sampling period showed an average concentration of only 0.07 and 0.08 mg/liter in the raw and settled sewage and none at all other locations. It was thus concluded that the treatment process was completely effective in removing phenol.

Radiological analyses for both alpha and beta activity were made during February and August. In February significant beta activity was measured in the waters at the inlet to the percolation area. This activity of 419 ± 18.2 micromicrocuries per liter was most likely due to heavy runoff that occured at this time. All other beta activity levels ranged from approximately 16 to 90 micromicrocuries per liter. Generally no significant alpha activity was found.

Table 12 — APPARENT ABS IN mg/liter

Location	Range	Average
Plant inlet	6.8 - 27	16.5
Secondary effluent	4.8 - 11	8.5
Pond effluent	4.2 - 9.7	6.7
Ground water 6.1	2.8 - 8.6	5.8
Ground water 6.2	0.9 - 2.4	1.7
Lake 4 inlet	1.5 - 5.2	2.9
Lake 4 outlet	1.4 - 5.0	3.0

DISCUSSION

The people of Santee have most recently demonstrated their backing of the Santee water reclamation project by voting 4 to 1 for a completely new sewage treatment plant. This new facility will be located up the valley from the present plant and will continue to provide water for the recreational lakes as well as other reuse. Certain inadequacies such as odor problems, associated with the oxidation pond, the digester, and the primary clarifier, have at times created complaints from downwind residents. Operational changes have frequently been made to counteract these problems. The experience gained in operating a plant under the conditions prevailing at Santee along with the successfully managed esthetics at the recreational lakes was important in management's decision to place the new plant in a different location.

The new site is ideal for further experiments in nutrient control. This is needed since the capacity of the aquifer is limited and the change in spreading area to increase hydraulic capacity has, in effect, increased the total nutrients in the waters entering the recreational lakes.

Santee waste waters have averaged 75 gallons per capita per day, and the quality has reflected the type of water use as well as the basic water supply quality. In planning for a major program of water reuse in the future, the District management can see the day when it must find a higher quality potable water source and must pay considerably more for it. Reuse of waste waters then for secondary purposes such as the recreational lakes or irrigation will be even more competitive.

Table 13 summarizes physical and chemical increments that are added to the waste water flow. The median coliform concentration based on the Santee population and rate of flow shows that contribution per capita is 140 billion coliform per day. The BOD concentration of 190 pounds per thousand persons per day appears normal when considering the use of home garbage grinders. If increments appear high, they are probably related to the high waste production from "our effluent society." Increments of chloride are related to the considerable softener recharge applied to Santee's extremely hard (300 mg/liter) water. Several small laundries and a geriatric hospital are in the area, but there is no industrial discharge that could affect the waste water quality. Future development of the Santee community can likely be kept compatible with its water reclamation.

Reductions of pollution, as measured by selected water quality indicators through the various treatment processes, are shown in Figure 15. The activated sludge treatment process appears normal for the removal of BOD and suspended solids but is below normal for removal of COD. Of note were occasional very low orthophosphate residuals. The activated sludge process may be appropriate to the control of phosphate in waste water.

The pond, as a treatment device, was effective in providing some removals of nitrogen, bacteria, and virus. It should be noted that the pond was loaded at 22 pounds of BOD per acre per day. DO measurements show the pond operates satisfactorily most of the time but is subject to upsets, especially during the fall and winter. When temperature drops occurred at these times, upwelling of bottom waters would occasionally cause odor conditions. The pond retention was effective in reducing the number of virus identifications. Although concentrations of phosphate coming out of the pond show little average reduction, some removal did occur at times.

Table 13 — WASTE-WATER INCREMENTS ADDED TO THE FLOW AT THE SANTEE PROJECT[a]

	lb/day per 1000 people	
Volatile suspended solids	320	
Fixed suspended solids	50	
BOD	190	
COD	700	
Total Nitrogen	38	
Orthophosphate	39	
Chloride	70	(above water supply at 95 mg/liter)
ABS	10.7	
Total dissolved solids	240	(above water supply at 750 mg/liter)

[a]Coliform at MPN $= 49 \times 10^6$/100 ml and flow 0.9 mgd for the population of 12,000 $= 140 \times 10^9$ per person/day.

The spreading area was an effective treatment device when the area could be operated within reasonable flow limits. At high flows, or when water was spread for more than about 24 hours, the water table would build up under the spreading area. This reduced treatment effectiveness and resulted in breakthrough of phosphate and ammonia nitrogen. The effectiveness of the ground for control of coliform remained unchanged by prechlorination. Approximately the same concentration of coliform, fecal coliform, and fecal streptococci organisms were found with or without prechlorination. The long path of travel through the aquifer was, however, effective in reducing all bacterial counts to very low levels. Figure 16 shows that the recovered waters at the inlet to the lake had ratios of fecal coliform/coliform and fecal streptococci/fecal coliform considerably different from that of a normal sewage effluent or the Santee effluent. These ratios of bacterial densities could arise from soil, animals, and birds, or could result from different die off rates, or from recovery or regrowth of inadequately "killed" organisms. Again, with chlorination of the recovered ground water flow, the lake waters were either recontaminated by soil, birds, or animals, or the waters cultured the regrowth or recovery of the three indicators to approximately the same levels as without chlorination. Since chlorination was much more effective at the lake inlet, the chances for recovery or regrowth would be very low, and lower levels of the indicator organisms would be expected. The effects of recontamination can also be verified by a comparison of ground water samples obtained from the ditch or from a pipe inserted into the saturated zone of the aquifer. Bacterial densities in the ditch at location 6.2 were always much higher than the very low counts obtained from the pipe. In spite of the recent history of the subject waste water, recontamination by the soil, birds, or animals would appear to account for the major portion of the bacterial densities in the receational lake waters.

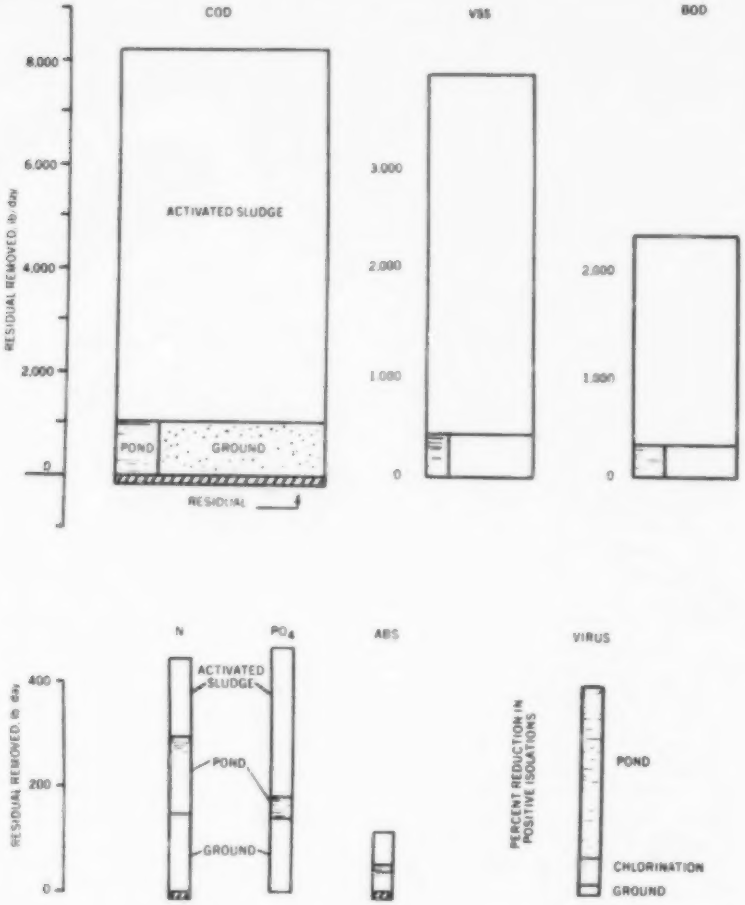


Figure 15 — Treatment system removals.

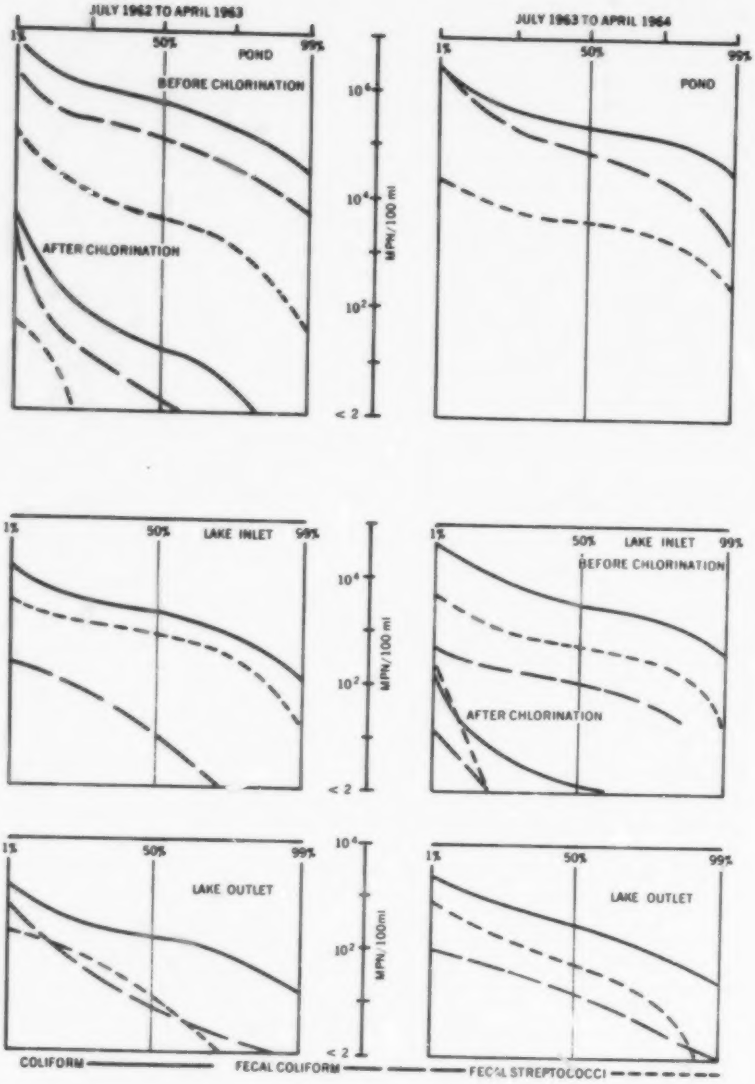


Figure 16 — Effect of chlorination on coliform, fecal coliform, and fecal streptococci — percent frequency of MPN/100 ml.

While the percolation system was an effective barrier to the transmission of virus, it futher contributed to the success of the lakes by assisting in the removal of both phosphorus and nitrogen. This removal was proportional to the time or distance of travel underground. During periods when spreading rates were equal to or less than the transmissibility of the aquifer, phosphate and total nitrogen levels in the waters entering the lake were always at levels of less than 1 mg/liter. When spreading rates exceeded the aquifer capacity the phosphate and total ammonia nitrogen levels in the first waters surfacing about 200 ft. below the spreading basins usually exceeded 10 mg/liter or, in other words, were about 30 to 50 percent of the levels applied to the basins. With the change in spreading area to a location at one side of the valley the distance of underground travel averaged in excess of 400 ft., and phosphate and total nitrogen levels have averaged about 8.0 mg/-liter. The nitrogen form found in waters below the spreading beds is primarily ammonia at all levels above 1 mg/liter. The surface of the spreading area has been scarified at 3 to 4 month intervals and shows a buildup of salt on the soil surface. This chemical precipitant has been found to contain calcium and magnesium phosphates and carbonates. No estimate of loss of spreading area effectiveness can be made from the limited experience at Santee. It can be concluded that the shallow aquifer not only limits the transmissibility but also restricts the downward movement of water in the mound that forms under the spreading area. A deeper aquifer would have been a great benefit to the project.

The study of virus at Santee has accomplished its primary purpose. It has been successful in gaining popular acceptance of swimming in the reclaimed water. It has also demonstrated to the satisfaction of the health officials that waste water can be monitored for this pathogen, and that waste treatment as used at Santee does control its presence. The procedures used in the virus study could be relied upon to show the presence of virus in the raw sewage of the community as well as in about 90 per cent of the secondary effluent samples. When the same procedures consistently failed to show the presence of virus in the reclaimed waters used for recreation, the restrictions originally placed on the project could be relaxed. Statements allowing increased use were more convincing when made by the same officials who previously had asked for the study.

The early attempt at an epidemiological study made during summer and fall 1963 surveyed, by questionnaire, 55 families in the Santee area. The survey, conducted by Harold R. Zeckel, M.D., while on duty with the California State Department of Public Health, was designed to determine, during the early (minimum contact) use of the facilities, whether or not users of the Santee lakes suffered any increase in minor illnesses as compared with non-users. Thirty-nine families kept complete day-to-day records noting any illness of any kind in each member of the family.

At the same time, a registry of persons coming to the lakes was made for each weekend when the lakes were open. This record showed an average attendance of 286 people per day during the time of the study. Fifty-five per cent of these were children and 50 percent lived in Santee. Also, approximately 35 percent of those coming to the lakes were from the same area covered by the minor illness survey.

The only significant information developed from the survey was a relationship between the number of sick days reported and the age of the individual involved. As would be expected the young were found to have more minor illness than those in the older age groups. Nothing significant was developed as to visitors to the lakes and non visitors.

In August 1964 this and all associated studies were reviewed by a Special Epidemiological Advisory Committee for the Director of California State Department of Public Health. This committee recommended expansion of the recreation program to include swimming in a separate area and under the same degree of surveillance as had been used for this study.

Following the swimming experience of 1965, the list of 3200 registrants was checked against morbidity records obtained by the San Diego County Department of Public Health for people living in Santee and surrounding areas. Although there were 15 reports of illnesses ranging from infectious hepatitis to shigella from this area, none of these was in the group of swimming participants. Realizing that morbidity records are incomplete, but by evaluation of laboratory results and the treatment process, it is reasonable to assume that the waters used in the swimming facility were bacteriologically and virologically safe.

The Santee Lakes have responded to the quality of the reclaimed water by supporting a diversified food chain from phytoplankton to fish. The plankton in the upstream lake of the series has been consistent in quality as long as inlet water conditions were uniform. Upsets or changes in the treatment caused algal blooms that reduced the clarity of the waters, although without detriment to the recreational use. The upstream lake has been successful in reducing a wide variation in inlet nutrient levels (2-10 mg/liter) to a consistent outlet concentration. The result of this reduction by phytoplankton has been a heavy deposit of algal sludge that has in turn occasionally helped to reduce oxygen levels. The addition of new lakes has served to equalize this accumulated sludge.

The downstream lakes have responded in turn to both water quality and the reduced summer flows by producing blooms of blue-green algae. These blooms have progressed from summertime only to year round persistence. When the wind conditions are still, these blooms create a paint like surface scum. Fortunately, winds are such that the scum is usually broken up during recreation periods. This condition has not interfered with the use of the lake for recreation. The blue-green algae blooms have created an additional build-up of sludge and are present in a greatly increased biomass because of the nitrogen fixation phenomenon. In August and September 1965, fish kills in all of the downstream lakes resulted from low oxygen levels. While the primary impetus for the kill was the very hot desert wind condition, the respiration of the blue-green algae as well as the oxygen demand of the residual sludge were jointly responsible. Since the kill, and appropriately during the winter of 1965, copper sulfate has been used to control the blue-green algae. The best method of control for the conditions causing the fishkill has not been determined, but control of sludge, by removal or aeration, and control of nitrogen-phosphorus inputs to the downstream lakes are suggested in addition to the use of copper sulfate.

Managed control of water quality in the lakes will have to be practiced to protect the fishery since the people of Santee now view the lakes with a proprietary interest. They have been willingly paid the slightly increased costs for sewage treatment and disposal to provide for the development of their lake and park area. The Santee community recently voted decisively to expand the water reclamation aspects and build a new treatment plant. Sewage treatment and disposal in this community appear to be tied irrevocably to water reclamation.

Another factor that has assisted in the development and encouraged the use of reclaimed water in the recreational lakes has been the cooperation between the major land developer in the Santee area and the water district. The land holdings of the developer have provided the area for recreation under an agreement that supplies reclaimed water to an adjacent golf course developed by the same owners. This golf course has always used reclaimed water from the district plant or lakes and was planned with this concept. The course is noteworthy because of the relatively large area (160 acres) that has been kept watered. This, of course, results from the large savings of about $100/ac. ft. over the use of domestic water. The course uses about 150 m.g. per year of the reclaimed water. As further water reclamation develops at Santee this waste water use will be joined with others on a common waste water distribution system. The contiguous character of the water reclamation units as now used and planned will give the small community of Santee a greenbelt area that is a forerunner of the future.

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APPENDICES

The purpose of these Appendices is to provide additional information for the readers who may wish to inquire further into the detail of this water reclamation project. Appendix A includes a background of how the project was organized and operated to assist in the motivation of people for the unusual accomplishments.

Appendix B lists summaries of contributions by the various agencies. In some cases actual detail of individual analyses are shown so that further study or interpretation can be made. In most instances summaries of individual analyses are presented with the original record being stored with the agency contributing the results or in the office of the Regional Office, IX, F.W.P.C.A.

A. General
   1. Memorandum of Understanding
   2. Proposed Study Plan for the Santee Water Reclamation Project
   3. State Department of Public Health Press Release

B. Summary of Technical Data
   1. California Department of Water Resources Aquifer Investigation
   2. Climatological Record — Precipitation, Temperature and Water Temperature
   3. California Department of Fish and Game Records
   4. Virus Isolations
   5. Virus Results of Test Well Sampling
   6. Total Virus Isolations by Month
   7. Percent Virus Isolations by Month
   8. Quarterly Study Period Bacterial Summary
   9. Bacteriological Record — San Diego Health Department Laboratory
   10. Genera of Phytoplankton
   11. Record of Most Abundant Genera of Algae
   12. Dissolved Oxygen Summary
   13. Chemical and Physical Characteristics of the Lakes
   14. Sampling Stations in Lake 4
   15. Stratification of Temperature and Dissolved Oxygen
   16. Benthonic Organisms; Progress Reports by Bureau of Vector Control, California Department of Public Health
   17. Composition of Fish Seining Catch
   18. Physical and Chemical Quality of Treatment

APPENDIX A-1

SANTEE WATER RECLAMATION PROJECT
MEMORANDUM OF UNDERSTANDING

April 13, 1962

I. The following agencies: United States Public Health Service, California State Water Pollution Control Board, California State

Department of Public Health, California Department of Water Resources, California Department of Fish and Game, San Diego County Department of Public Health, and Santee County Water District, agree that the currently operated sewage treatment and water reclamation facilities of the Santee County Water District present an ideal opportunity for studying the reuse of waste water for recreational and recharge purposes. These agencies therefore have agreed to join in a cooperative study to be known as the "Santee Water Reclamation Project." Each agency shall have at least one representative on a Project Advisory Committee which will guide the project.

II. Contributions of resources by each of the above agencies to this project in fiscal years 1961-62 and 1962-63 shall include but not be limited to the following:

  A. The United States Public Health Service agrees to provide:
    1. The project coordinator, available as necessary,
    2. The project report, including a monthly summary of accomplishments,
    3. Support for certain aspects of the project, including weekly chemical and biological analyses and consultation on aquatic biological aspects,
    4. Support, if necessary, for enterovirus determinations in The San Diego County Health Department laboratory,
    5. Assistance and technical support as necessary from the staff of the Sanitary Engineering Center in Cincinnati, Ohio, and,
    6. Support to the Santee County Water District to make beneficial changes in the percolation area to provide for optimum treatment of the waste waters.

  B. The California State Department of Public Health agrees to provide:
    1. A mobile laboratory with two chemists and a laboratory assistant to perform the four-hour cycle of bacterial and related chemical determinations for two-week periods, four times per year, on or about the first of February, May, August, and November.
    2. An epidemiology traineeship (as M.D.) assigned full-time to the project to make an epidemiological study of recreational users at the Santee Lakes.
    3. Radioactivity determinations as frequently as the project coordinator decides to be necessary, and
    4. One-fourth to one-half time of a vector control technician.

  C. The California State Department of Water Resources agrees to provide:
    1. Assistance for sampling transportation and chemical analyses during each of the two-week periods the State Health Department mobile laboratory is on the site,

2. A ground water — hydrology study of the Sycamore Basin,
3. A flow rating device and two water stage recorders as required on the project, and
4. A recording conductivity meter for monitoring of water quality during the intensive two-week sampling periods.

D. The California Department of Fish and Game agrees to provide:

1. General assistance in the fish management program,
2. Fish for stocking purposes and study as needed and as the supply will permit,
3. Fish handling equipment including nets, etc., and
4. Assistance in sampling fish and other aquatic organisms as time, personnel and equipment will permit.

E. The San Diego County Department of Public Health agrees to provide:

1. Office space and stenographic services for the project coordinator and epidemiologist trainee,
2. Laboratory analyses for coliform, fecal coliform and fecal streptococci for the eight weekly samples obtained from various locations in the project during the intervening periods between mobile laboratory assignments,
3. Laboratory studies of enteroviruses in the sewage and waste water in accord with recommendations of the technical advisors to the project within the capability of the support of the California Water Pollution Control Board and United States Public Health Service,
4. Field and laboratory examinations for gnat and mosquito larvae at possible two-week or weekly intervals during their growing season, and
5. Transportation of all samples from Santee to the laboratory.

F. The Santee County Water District agrees to provide:

1. Access to and the use of the sewage treatment and water reclamation facility including the spreading grounds and recreational lakes for the research study.
2. Working space, water, electric and waste water services as necessary for the mobile laboratory or other on-site tests performed in this study,
3. All bacterial and chemical sample collection and gage height and flow measurements at four-hour intervals during each two-week intensive sampling period and weekly during the intervening periods,
4. Operating changes in the treatment procedures or facility according to the Research Plan or when significant results of laboratory analyses make a change desirable to provide new data,

5. Records of plant operation including flow records and operating changes and results of any field tests performed by plant personnel,
6. Assistance in establishing additional wells to monitor ground water movement and quality, and
7. Assistance to the technical staff in the various activities associated with the project.

III. The proposed research program has the overall goal of utilizing the sewage reclamation plant and recreation facility operated by the Santee County Water District to provide information regarding the degree of treatment necessary to make a reclaimed water suitable for recreational use, replenishment of ground water, and other possible beneficial uses. The agencies participating in the project agree, however, that any beneficial changes in the research program that can be provided by increasing the number of participants or the range of research will be acceptable.

APPENDIX A-2

PROPOSED STUDY PLAN FOR THE SANTEE WATER RECLAMATION PROJECT

October 31, 1961

Prepared by
Roderick F. Bott, Public Health Engineer
San Diego County Department of Public Health
San Diego, California

CONSULTANTS:

Paul W. Eastman — Regional Program Director
San Francisco — U. S. Public Health Service

Paul W. Kabler — Chief, Microbiology Section
Cincinnati — U. S. Public Health Service

Francis M. Middleton — Chief, Advanced Waste Treatment
Cincinnati — U. S. Public Health Service

E. A. Reinke — State Sanitary Engineer
California State Department of Public Health

SANTEE WATER RECLAMATION RESEARCH PROJECT

Santee County Water District
San Diego County, California

I. *Objective* — To determine the effects of varying degrees of sewage treatment in the field on the chemical, physical, bacterial and viral content of waste waters to be used for irrigation, ground water recharge, and water sports (particularly water contact sports).

A. Initial Objectives

1. Determination of in-field efficiency of activated sludge process in such removals.
2. Determination of in-field efficiency of activated sludge process plus stabilization pond treatment for different detention periods up to 86 days in such removals.
3. Determination of in-field efficiency of activated sludge process plus chlorination up to 80 ppm in such removals.
4. Determination of in-field efficiency of activated sludge process plus stabilization pond treatment (as in 2.) plus chlorination up to 80 ppm in such removals.
5. Determination of in-field efficiency of activated sludge process plus field percolation through natural sand and gravel in such removals.
6. Determination of in-field efficiency of activated sludge process plus stabilization pond treatment (as in 2.) plus field percolation through natural sand and gravel in such removals.
7. Determination of in-field efficiency of activated sludge process plus stabilization pond treatment (as in 2.) plus chlorination up to 80 ppm plus field percolation through natural sand and gravel in such removals.
8. Epidemiological study of a generally stable, uniform and readily identifiable community of persons who use the reclaimed water for recreational purposes.
9. Determination of quality criteria for fresh waters used for sports, particularly contact sports (e.g., swimming and water-skiing).
10. Determination of the optimum amount of treatment required to provide adequate protection to the public in a variety of uses of reclaimed water (direct contact in recreation, for irrigation of crops or of recreational areas such as golf courses, and for ground water recharge.

II. *Description*

The unincorporated community of Santee lies along both sides of the San Diego River channel for a distance of six miles, beginning approximately fifteen miles above the river mouth. It is located just north from the City of El Cajon and about twenty miles by road from downtown San Diego. The community is largely residential with only such commercial establishments as are necessary to provide for community needs and services. It covers the junctures of both El Cajon Valley and Sycamore Canyon with the San Diego River Valley. There is no waste producing industry in the community.

Sycamore Canyon is a tributary of the San Diego River which contains no surface flow under present conditions. There is subsurface flow, however, both in the San Diego River and in

Sycamore Canyon. The canyon extends generally northward from the San Diego River channel to a point slightly over two miles from its junction with the river channel. At this point, the canyon divides, a westerly branch extending into the Camp Elliott Naval Reservation and the easterly branch located in private lands. The easterly branch is available for future subdivision and development as residential and recreational areas.

The floor of the canyon is approximately 2,000 feet in width at its mouth and narrows to approximately 1,000 feet in width to a distance of approximately two and a half miles above the mouth of the canyon. At this point, the floor of the canyon debouches into a rolling plain approximately three to four square miles in area. The canyon then extends additionally northerly. A natural spring located in the northerly end of the large level area discharges water into the underground formation and provides a subsurface flow which extends to the junction of the canyon with the San Diego River. The floor of the canyon is underlain with a layer of clay of undetermined thickness. This serves to confine the underground stream percolating through a sand and gravel formation which overlays the clay layer to a depth of from eight to ten feet.

The area immediately up-canyon from the location of the sewage treatment plant, indicated as Site A on the attached map, has been extensively worked by a gravel processing industry to a depth of from eight to ten feet. The remaining borrow pits have been reworked into level areas with earthern berms to provide oxidation ponds or lakes to receive the sewage treatment plant effluents. Areas farther up-canyon will continue to be worked as time goes by and this will result in the creation of additional lakes.

The area immediately to the east of the canyon and generally indicated as lying above the 375 to 400 foot contour is occupied by a development which contains 1,720 residences and extends northward approximately one mile from the mouth of the canyon at the present time. The area immediately to the west of the treatment plant site has also been subdivided and is occupied by 185 residences at the present time.

The master plan for development of the canyon provides for a flood channel extending along the entire westerly boundary of the canyon. It also provides for a freeway extending along the easterly edge of the canyon. Between the flood channel and the freeway are located the treatment plant and oxidation ponds which are maintained and operated by the sewering agency.

III. *Treatment Facilities*

The Santee County Water District is a public agency which provides water for the residential areas described above, in addition to considerable other area as indicated on the map. The

County Water District is also the sewering agency for this entire area. The present tributary flow to the County Water District sewage treatment plant is 600,000 gallons per day. The sewage is treated in an activated sludge type sewage treatment plant which has a capacity of two million gallons per day. Effluent from the sewage treatment plant is discharged into the first of a series of stabilizing basins or oxidation ponds.

The proposal of the County Water District officials was to utilize the progression of stabilization basins — four in number — which have been constructed extending northerly from the sewage treatment plant to obtain tertiary treatment and stabilization of the activated sludge treatment plant effluent. The plan titled "Figure 1 — Proposed Water Reclamation Plan," indicates the layout of the stabilization basins. These basins have been formed by the sewering agency in an effort to beautify the areas which have been despoiled by the gravel pit operations.

The elevation of the water surface in the basins increases as the individual basins extend northward. The original plan proposed to pump the treatment plant effluent serially from Lake 1 to Lake 2 and to Lake 3. At the present rates of flow (0.6 mgd) arriving at the sewage treatment plant, Lake 1 has a detention capacity of 41 days; Lake 2 has a detention capacity of 20 days; Lake 3 has a detention capacity of 25 days. The total detention time in the three ponds is, therefore, 86 days. Between Lake 3 and Lake 4 is located a chlorination facility with a capacity to feed 400 pounds of chlorine per day to water pumped from Lake 3 to a chlorine contact tank before discharge into Lake 4.

Upon rejection of the initial proposal, the sewering agency offered an alternate plan. Under this plan, it is proposed to pump effluent from Lake 1 to a spreading basin located approximately 6,000 feet northerly of Lake 1. At this location, it is expected that the effluent will percolate into the soil and mix with native waters which underlie the surface of the ground. It will then flow one half mile in a southerly direction toward Lake 4. Immediately upstream from Lake 4 there has been constructed a horizontal gallery from which it is proposed to pump water for delivery into Lake 4. Effluent from Lake 1 will be chlorinated to a residual of 7.0 ppm of free chlorine after 30 minutes contact previous to percolation in the spreading basins.

Lake 4, with an area of eleven acres, is proposed as a recreational lake to which the public is invited to engage in such activities as picnicking, boating and fishing. The sponsors of the recreational project envision unlimited recreational use of more remote lakes at some future time. The total area around all of the lakes is fenced by chain link fencing and Lake 4 is separated from Lake 3 by a chain link fence. The entire area has been landscaped and includes islands constructed around trees which remained from the previous gravel operations. Lawns have been developed and fireplaces built in the picnic areas. The entire development indicates good operation.

The overflow from Lake 4 will be by gravity through Lake 3 and Lake 2 in series. From Lake 2, the overflow will be to the flood channel extending along the westerly boundary of the canyon. Pumps are in place between the lakes and the flow through Lakes 2 and 3 can be reversed as originally planned with any discharge from Lake 4 to the flood channel.

IV. *Method of Study*

A. *Establishment of sampling points*

1. Raw sewage
2. Primary (settled) effluent
3. Activated sludge plant effluent
4. Stabilization pond effluent
5. Chlorinated stabilization pond effluent
6. Percolated water (through various distances of natural sand and gravel)
7. Recreational lake
8. Ground water above spreading basin to establish quality and quantity of flow.

B. *Frequency of Sampling*

Will vary with kind of analyses (i.e. chemicals daily at the beginning then semiweekly or weekly after pattern is established.)

C. *Observations Recorded*

Temperature (air and water), solar radiation, evaporation, turbidity (pond), wind direction and velocity, precipitation, overflow, population using recreational lake (Lake #4) and activities, D.O., volumes of flow at various sampling points.

D. *Determinations*

SAMPLING POINT	Raw Water	Raw Sewage	Primary Settled Effluent	Activated Sludge Effluent	Pond 1 Effluent	Pond 1 Effluent Chlorinated	Ground Water Above Spreading Basin	Collection Gallery	Pond 4
Enteroviruses	X	X		X		X		X	X
Coliform	X	X	X	X	X	X	X	X	X
Fecal Coli	X	X	X	X	X	X	X	X	X
Fecal Streptococci	X	X	X	X	X	X	X	X	X
Chemical Oxygen Demand	X	X	X	X	X	X	X	X	X

SAMPLING POINT	Raw Water	Raw Sewage	Primary Settled Effluent	Activated Sludge Effluent	Pond 1 Effluent	Pond 1 Effluent Chlorinated	Ground Water Above Spreading Basin	Collection Gallery	Pond 4
BOD (Correlate With COD)		X	X	X			X	X	
Tot. Kjeldahl Nitrogen	X	X	X	X	X	X	X	X	X
NH_3		X	X	X	X	X	X	X	X
NO_2				X	X	X	X	X	X
NO_3	X			X	X	X	X	X	X
PO_4	X			X	X	X	X	X	X
CA CO_3	X	X		X	X		X	X	X
Complete Mineral (Only 1 or 2 to Establish Pattern)	X	X		X	X		X	X	X
ABS		X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X
Alkalinity		X	X	X	X	X	X	X	X
Total Solids	X	X	X	X	X	X	X	X	X
Suspended Solids		X	X	X	X	X	X	X	X
Volatile Solids		X	X	X	X	X	X	X	X
Carbon Filter							X	X	
Residual Chlorine Free & Combined						X		X	X
Phenols		X	X	X	X	X	X	X	X
Chlorides	X	X	X	X	X	X	X	X	X
Plankton Identification					X	X			X
Benthic Organisms					X				X
Mosquito & Gnat Larvae					X				X
Radioactivity Gross Alpha & Beta					X	X	X	X	

To Determine Bacteriological and Viral Quality of Water

Bacteriological

1. Raw sewage as below
2. Of the activated sludge effluent — Sample every 3 to 4 hours for 10 to 14 days (each season)

Determine coliforms, fecal coliforms (45°C) and fecal streptococci (dechlorinated samples)

a. Coliforms — standard methods 5 tubes, lauryl sulphate tryptose broth (L.S.T.) confirmed in brilliant green lactose broth, with enough completed tests to insure accuracy of the confirmed tests, or — in samples where turbidities do not interfere, the S.M. membrane filter test may be used.

b. Fecal coliforms, 5 tubes decimal dilutions, presumptive in L.S.T., 24 and 48 hours at 35.0 C, confirm positives (at 24 and 48 hours) in EC broth 24 hours at 45°C. For 45.0°C incubation, use water bath having 44.5°C and 45.5°C as minimum and maximum temperature range.

c. Fecal streptococci — Membrane Filter method with KF medium or KF agar Plate count, both at 35.0°C. (± 0.5°) for 48 hours. (See Fecal Streptococci I. Cultivation & Enumeration of Streptococci in Surface Waters, Applied Microbiology 9:1, 15-20, Jan. 1961, and Fecal Streptococci II. Quantification of Streptococci in Feces. Amer. Jour. Pub. Health, 50:10, 1553-1559, Oct. 1960.)

Subsequent tests for specific identification can be made by picking colonies from either method. Depending on results, it may be possible to examine daily or twice weekly composites using same test procedures.

3. Can use same basic schedule for examining post chlorination samples, water in infiltration gallery and/or in ponds.
4. In ponds must use 6-12 points, to determine effects of mixing, currents, winds and layering, taken some at top and some at bottom.

Virological

Using tissue culture of continuous cell lines (number and kinds to be determined) and/or new-borne mice or other appropriate methods.

Determine presence (quantitative) of enteroviruses in
Raw sewage
Activated sludge effluent
Activated sludge effluent postchlorinated
Ground water above spreading basins
Water from collection gallery (infiltrated) and for each pond if indicated.

Probably will desire to use composite samples because of facility and personnel limitation.

E. *Methods Used*

1. Standard methods where available
2. Otherwise as recommended by U.S.P.H.S.

V. *Sequence of Studies* — These studies to the extent which demonstrates optimum results.

A. Evaluation of data on residual substances and organisms from activated sludge process alone in the light of existing information for such treatment and the criteria for uses of receiving waters as contained in the publication "Water Quality Criteria" currently under revision by the California State Water Pollution Control Board and the United States Public Health Service at the California Institute of Technology. This item can be carried on simultaneously with any and all of the following separate studies.

B. Evaluation similar to "A" of results of treatment by activated sludge plus stabilization pond detention of

1. 20 days
2. 25 days
3. 41 days
4. Combination of "1", "2", and "3" (i.e., 45, 61, 66 or 86 days)

C. Evaluation similar to "A" of results of treatment by "A" plus chlorination. Rate of chlorine application and contact time variable as desired.

D. Evaluation similar to "A" of results of treatment by "A" plus "B" plus chlorination. Rate of chlorine application and contact time variable as desired.

E. Evaluation similar to "A" of results of treatment by "A" plus percolation. Percolation distance variable as desired.

F. Evaluation similar to "A" of results of treatment by "C" plus percolation. Percolation distance variable as desired.

G. Evaluation similar to "A" of results of treatment by "D" plus percolation. Percolation distance variable as desired.

H. Evaluation of results of epidemiological study of persons using recreational lake filled by effluent from the different methods of treatment mentioned previously.

VI. *Significance of Research*

Waste water reclamation is receiving much attention and interest in semi-arid parts of the nation. Native fresh inland water for recreational purposes is practically non-existent and much thought is being given to uses of sewage plant effluents in the form of reclaimed water. In this county alone, at least two golf courses are being irrigated with sewage treatment plant effluents and other projects of similar nature are in formulation. In addition, hundreds of acres are being irrigated with sewage plant effluents in commercial flower culture.

The present proposal concerns itself with more direct contact by the public with the sewage plant effluents and, due to its peculiar arrangements, lends itself to a study on the effect of variations in the advanced stages of sewage treatment on the removal of enteroviruses and other undesirable organisms and substances from treated sewage effluents. Various local, state and Federal agencies have great need for information of the type sought in this proposed research project.

VII. *Facilities Available*

In addition to the treatment facilities and recreational lake (to which admission is controlled) of the Santee County Water District, the following resources are available for carrying out the project:

A. San Diego County Health Department — bacteriological determinations, engineering consultation, and small amount of space for other cooperating technical personnel.

B. California State Health Department—virological and certain chemical determinations and engineering consultation. (Epidemiology?)

C. United States Public Health Service, Department of Health, Education and Welfare, Region IX — leadership, coordination and technical services of biologist and engineer.

D. United States Public Health Service, Sanitary Engineering Center — consultation on microbiology (including virology), physical and chemical aspects, analytical reference service.

E. United States Public Health Service, Communicable Disease Center — epidemiological assistance.

F. California State Water Pollution Control Board and Regional Water Pollution Control Board — consultation and possible financial assistance to be determined as needed.

G. California State Department of Water Resources — certain chemical determinations; engineering consultation and evaluation of results.

H. Santee County Water District Sampling, local records and variation in plant operation to permit evaluation of different treatment combinations.

APPENDIX A-3

STATE DEPARTMENT OF PUBLIC HEALTH
2151 Berkeley Way, Berkeley
THornwall 3-7900, Ext 311

For Immediate Release

Berkeley — Swimming will be permitted in a limited area in the Santee Water Reclamation project providing strict sanitary safeguards are maintained, it was announced by Dr. Malcolm H. Merrill, state health director.

The director, following the recommendations of his Epidemiology Advisory Committee to the Santee Project, said biological, hydrological, bacteriological and virological information shows that certain areas of the Santee development can be opened to broader recreational use.

But with these provisos, he added:

1. That the proposed swimming area be developed and maintained in accordance with established standards for artificial pools in California.

2. That the San Diego County Health Department maintain a constant laboratory surveillance and continued evaluation of the recreational programs.

The conclusion to allow swimming, Dr. Merrill said, is contingent upon the maintenance of strict sanitary safeguards including filtration of the reclaimed water through the ground.

He said the Santee project for reclaiming waste waters for recreational use extends well beyond local and state interests and if its full potential can be realized, will be of benefit in other areas which suffer from a water shortage.

The advisory group, appointed last spring by the State Board of Public Health to advise the department on the uses of Santee, includes Dr. James C. MacLaggan, San Diego pediatrician and chairman of the Commission on Public Policy of the California Medical Association; Dr. Alexander D. Langmuir, head of the Epidemiology Branch of the U. S. Public Health Service Communicable Disease Center, Atlanta, Ga.

Dr. K. F. Meyer, director emeritus of the Hooper Foundation University of California Medical Center, San Francisco; Dr. A. F. Rasmussen, chairman of the Medical Microbiology and Immunology Department, University of California, Los Angeles, and Dr. Paul F. Wehrle, professor of pediatrics at the University of Southern California Medical School.

APPENDIX B-1

EDMUND G. BROWN
GOVERNOR
STATE OF CALIFORNIA
Department of Water Resources
Los Angeles
June 18, 1962

Mr. John C. Merrell
United States Public Health Service
Primary Health Center
Civic Center
San Diego, California

Dear Mr. Merrell:

This letter summarizes the results of our recent studies on the effects of natural stream underflow and surface flow through Sycamore Canyon on the water reclamation project of the Santee County Water District.

The features of the reclamation project are shown on Plate A, "Location Map," which accompanies this letter, and include an upstream percolation area and four lakes located in the canyon. Lake No. 4 of the project receives water from two sources:

1) Treated waste effluent, which is pumped from the Santee County Sewage Treatment Plant, spread in the percolation area, and collected in the infiltration gallery, before entering the lake.
2) Natural stream underflow and surface runoff from Sycamore Creek.

The purpose of our study was to determine the proportionate contribution of each of these sources to the waters of the lake.

The quantities of treated waste effluent spread in the percolation area were easily determined by direct measurement at the treatment plant; they amounted to about 700,000 gallons per day. However, in order to determine the amount of natural stream underflow and surface runoff entering the lake, it was first necessary to ascertain the geologic and hydrologic characteristics of Sycamore Canyon, in the vicinity of the project.

The general geology and hydrology of this area are briefly discussed in a report to the San Diego Regional Water Pollution Control Board from the Department of Water Resources, "Ground Water Geology, San Diego River Valley," dated December 1959. The rock types in the immediate area consist of gray siltstones, clays, and clayey sandstones belonging to the Rose Canyon Shale formation of Eocene age. These sediments are essentially nonwater-bearing. Sycamore Canyon was incised through these materials and backfilled with alluvial sand and gravel to depths reaching 15 feet.

To determine the configuration of bedrock in the canyon and the physical characteristics of the alluvial materials, six test holes were dug at a test section located approximately 2 miles upstream from the Santee County Sewage Treatment Plant. As shown on Plate A, the test section was located upstream from the percolation area of the reclamation project to preclude effects of the spreading operation from the natural underflow data.

A plan view of the test hole location is shown on Plate B, "Profiles of Sycamore Canyon near Santee," which also accompanies this letter. Using a back-hoe and a D-7 tractor, holes 1 through 5 were dug along the test section; observation hole "A" was dug about 420 feet downstream and well casing was installed in this hole. Casing was also installed in hole 3, and this hole was redesignated observation hole "B". Observation holes "A" and "B" were used to determine water table gradients, and data from all holes were used to prepare the bedrock profile and to determine the wetted alluvial cross-sectional area of the channel. Bedrock profiles and a table showing wetted alluvial cross-sectional areas versus water level elevations in observation hole "B" are shown on Plate B.

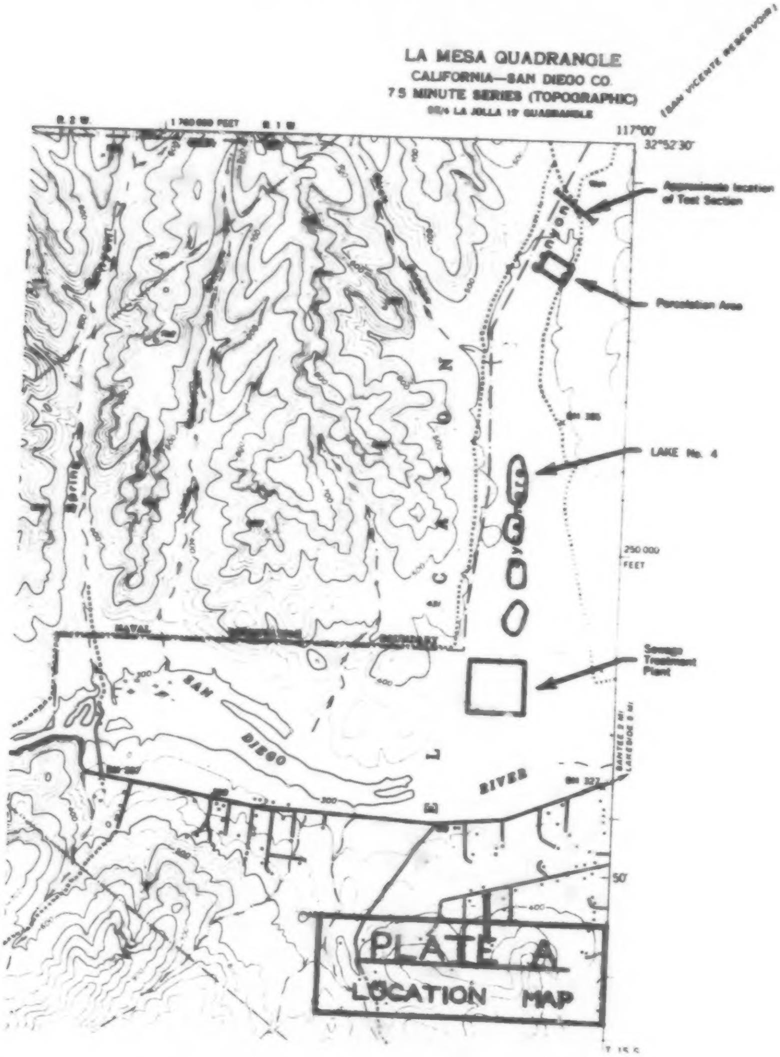
LA MESA QUADRANGLE
CALIFORNIA—SAN DIEGO CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SE/4 LA JOLLA 15' QUADRANGLE
(SAN VICENTE RESERVOIR)
117°00'
32°52'30"
R 2 W
1 760 000 FEET
R 1 W
Approximate location of Test Section
Percolation Area
LAKE No. 4
250 000 FEET
Sewage Treatment Plant
SAN DIEGO
RIVER
NAVAL
BOUNDARY
SANTEE 2 MI.
LAKESIDE 5 MI.
50'
PLATE A
LOCATION MAP
T. 15 S.

Plate A — Location map.

Reproduced from best available copy.

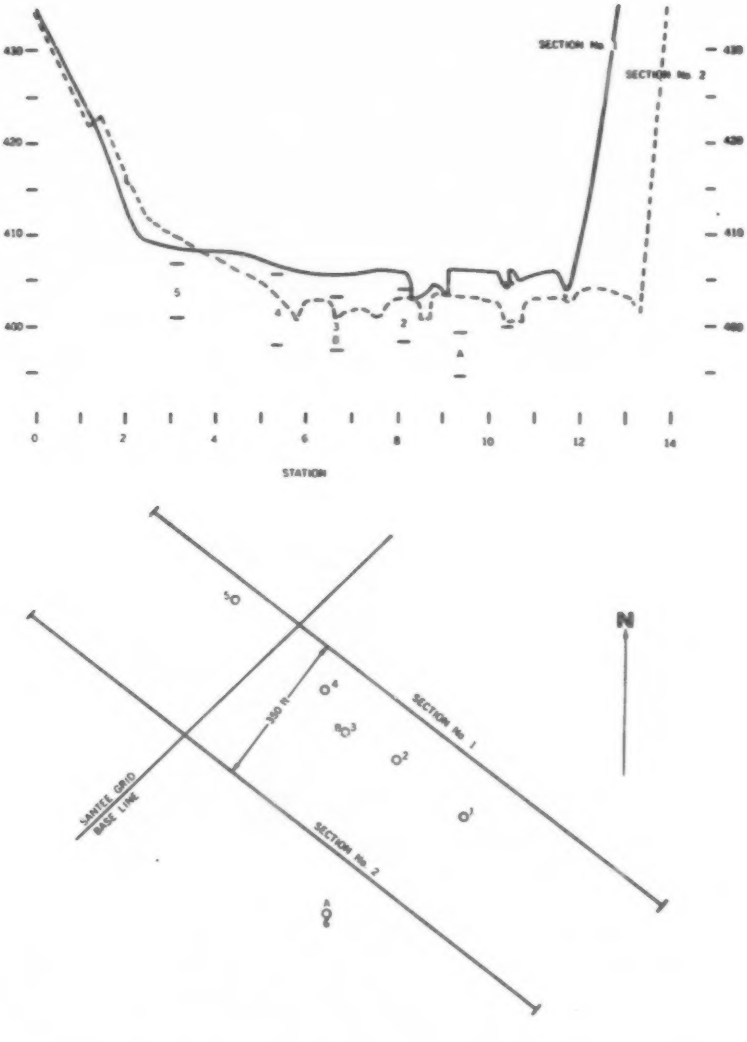
430
420
410
400
SECTION No 1
SECTION No 2
5
4
3
B
2
A
0
2
4
6
8
10
12
14
STATION
N
5
4
B 3
2
1
A
350 ft
SECTION No 1
SECTION No 2
SANTEE GRID
BASE LINE

Plate B — Profiles of Sycamore Canyon near Santee.

Channel alluvium was found to be relatively uniform throughout, consisting of silty fine to coarse sand with gravel, cobbles, and stone boulders. Sedimentary bedrock consisting of either siltstone or poorly cemented sandstone was encountered in holes 1, 2, 4, and 5. Bedrock was not reached in observation hole "B" (3); however, this hole was dug at a spot which had been excavated to bedrock previously and backfilled; information on the approximate depth to bedrock at this point was furnished by the equipment operator who had performed the previous excavation.

The permeability of the alluvial material could only be estimated because of the irregular composition and cobble content of the material. Determination of permeability by laboratory methods would have been extremely difficult and was felt to be beyond the scope of this investigation. Therefore, an estimated value was assigned, based on comparisons with samples of alluvium with known permeability. This comparative method yielded a permeability figure of 1,000-1,500 gpd/ft², with 1,500 gpd/ft² considered to be the probable upper limit. The value of 1,000 gpd/ft² was selected as the representative permeability and used in computing the underflow.

The first computations of underflow were based on data taken during January and early February 1962, when surface flow in Sycamore Creek was negligible. Underflow per unit time was calculated using the hydrologic equation:

$$Q = PIA$$

(Underflow = permeability × gradient × wetted alluvial cross-sectional area)

Based on the permeability value given earlier (1,000 gpd/ft²), the underflow through Sycamore Canyon during the early part of February is estimated to have been a maximum of 15 gallons per minute, or approximately [illegible]2,000 gallons per day. Typical results are given below:

	Water Level Elevation			Cross-section	
Date	Hole A	Hole B	Gradient	Area	Underflow
February 5, 1962	391.71	395.49	.009	2,471 ft²	15 gpm = 22,200 gpd
February 9, 1962	393.05	395.68	.00626	2,611 ft²	11 gpm = 16,300 gpd

It will be noted that during the period February 5-9, water levels in observation hole "B" rose only slightly, whereas in observation hole "A" they rose approximately 2 feet, creating a reduced gradient on February 9. It is believed that water levels in observation hole "A" may have been affected by a small ground water mound, probably created by the spreading of waste effluent in the percolation area; a ground water mound of this nature would influence the direction of ground water movement at this site. However, this change in water table gradient does not affect the validity of the test results.

A second determination of underflow was made based on data taken on March 22, 1962. Sycamore Creek was flowing at this time due to precipitation that occurred during late February and the early part of March; the surface flow through the test section, based on stream flow measurements, was estimated to be 100 gallons per minute.

In addition to water level measurements taken at observation holes "A" and "B" on that date, the water level elevation was also obtained from a well approximately 500 feet upstream from the test section; this well is shown on Plate B as the "old" well. Water levels at these three points were as follows: observation hole "A", 395.0 ft.; observation hole "B", 401.3 ft.; "old" well, 407.8 ft.

Using a permeability of 1,000 gpd/ft^2, a gradient of 0.0142, and a wetted cross-sectional area of 7,125 square feet, an underflow of 70 gpm, or 100,000 gallons per day was computed to have occurred during this period of higher water levels. Total flow through the test section, including the Sycamore Creek surface flow of 100 gpm, was estimated to have been 170 gpm or 244,000 gallons per day.

The following assumptions were made in determining the proportionate contribution of natural stream underflow, surface flow, and waste effluent to the waters of Lake No. 4:

1) All natural stream underflow passing through the test section enters the lake.
2) All surface flow bypasses the infiltration gallery of the project.
3) There is no percolation of surface flow between the test section and the infiltration gallery.

Based on these assumptions, it is estimated that a maximum of 22,000 gallons per day of natural stream underflow was added to the waters entering Lake No. 4 in February, and approximately 100,000 gallons per day on March 22. With about 700,000 gallons per day of treated waste effluent spread in the percolation area, these amounts of natural stream underflow would comprise approximately 3 percent and 13 percent, respectively, of the water supply to Lake No. 4. If a portion of the natural stream underflow bypasses the infiltration gallery of the project, the percentage of natural stream underflow entering the lake would be even further diminished.

It is concluded that the surface flow and natural stream underflow of Sycamore Creek contribute relatively small quantities to the waters of Lake No. 4. A more detailed and extensive study could be undertaken if the proportionate contribution of these sources has to be known with greater accuracy. In view of the findings of this study, however, it is believed that a more comprehensive study would not be justified, and it is recommended that it not be undertaken at this time.

Sincerely yours,
Herbert A. Howlett
District Engineer, Southern District

APPENDIX B-2

CLIMATOLOGICAL RECORD
PRECIPITATION AND TEMPERATURE AT GILLESPIE FIELD
(2 miles southeast of Santee)

	Precipitation, in.				Air temperature, °F							
					Maximum				Minimum			
	1962	1963	1964	1965	1962	1963	1964	1965	1962	1963	1964	1965
Jan.	3.45	0.72	1.49	0.44	84	82	88	88	23	22	24	27
Feb.	4.07	1.98	0.81	1.10	76	96	81	86	31	38	27	24
March	1.17	1.79	2.15	.91	78	82	85	83	30	33	31	29
April	T	1.24	0.64	4.29	93	83	96	97	43	36	38	37
May	0.81	0.09	0.69	T	88	87	87	91	45	42	43	40
June	0.03	0.13	0.01	T	93	90	93	86	49	47	44	47
July	T	0.00	T	0.07	94	94	98	93	52	48	51	51
August	0.00	0.01	T	0.00	98	95	97	101	56	52	53	55
Sept.	0.00	2.40	T	0.33	100	111	99	95	52	55	47	46
Oct.	0.01	0.34	0.12	T	97	89	103	101	44	46	41	41
Nov.	0.01	1.98	1.59	5.96	90	88	92	90	33	33	28	35
Dec.	0.36	0.12	1.15	4.61	82	87	80	89	26	26	22	31
Total	9.91	10.80	8.65	17.71	100	111	103	101	23	22	22	24

Temperature range 1951-1965	Maximum 111	Minimum 19
Annual precipitation 1929-1959	Average 13.8	

Water Temperature Summary (average °F, 11 a.m.)

Sampling period	Location 3	4	5	6.0	7	8
Feb. 1962	68	a	61	63	60	60
May	74	72	72	67	75	74
Aug.	82	83	81	a	80	79
Nov.	74	67	65	a	68	64
April 1963	70	73	70	67	69	68
July	79	82	78	75	79	79
Oct.	78	72	72	74	73	70
Jan. 1964	66	55	53	63	55	50

[a]No record.

APPENDIX B-3

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
Rm. 4000, Calif. State Bldg.
1350 Front Street
San Diego, California
October 21, 1965

Mr. John C. Merrell
U.S.P.H.S.
County Administration Bldg.
c/o San Diego County Public Health Dept.
San Diego, California 92101

Re: A summary of management activities of the Department of Fish and Game at Santee ponds from January 1, 1964 to October 1, 1965.

Dear Sir:

The Department of Fish and Game, for the past two years, has attempted to do the following three things at Santee:

(1) Stock predator species in ponds 3 and 4 to reduce and control a stunted, superabundant panfish population and establish more game fish. Panfish were removed for stocking in other waters as a part of this program.

(2) A simple food chain was established in pond 5 which will, hopefully, produce only game fish without panfish and the problem inherent to their management.

(3) All male *Tilapia* hybrids were stocked as an experimental warmwater research project to evaluate their growth, catchability and over-winter survival.

The following information relates how these three goals were implemented during the time period, changes which occurred at the ponds due to fish kills, and recommendations for future management.

A. Stocking: — Table 1 summarizes the stockings which were made during this time period.

The stocking of Pond 5 with bass and threadfin shad should provide some bass fishing in 1966 followed by even better fishing in 1967, provided that there are no introductions of panfish or the occurrence of severe fish kills. Some rescued channel catfish and bass were stocked in Pond 5 by Santee personnel during the September 8, 1965 fish kill.

In addition to the stockings, fishes were also removed from the ponds for stocking in other waters. Table 2 summarizes these removals.

TABLE 1.

FISH STOCKING AT SANTEE Jan. 1, 1964 to Oct. 1, 1965.

DATE	POND	SPECIES	NO. PLANTED	SOURCE
6-16-64	3	LMB	100	CFB[1]
	4	LMB	100	CFB
8-12-64	3 & 4	LMB	2,000	CFB
10-26-64	3	CCF	1,280	CFB
10-26-64	4	CCF	1,280	CFB
4-12-65	5	TFS	750	Pond 3
4-16-65	5	LMB	28	Miramar Res.
6- 7-65	2	Tilapia	1,120	CFB

[1] CFB = Chino Fisheries Base, Chino, Calif.

TABLE 2.

FISH REMOVAL RECORD January 1, 1964 to October 1, 1965.

DATE	POND	SPECIES	NO. REMOVED	WATER PLANTED
5- 7-64	4	RSF	484	Ramer Lake
11-24-64	3 & 4	RSF	64	Lakeside — San.
		TFS	80	District Oxid.
		BG	1	Ponds
4-12-65	3	TFS	750	Pond 5
5-14-65	3	TFS	1,500	Miramar Res.
7- 7-65	3	RSF	170	Miramar Res.
		TFS	80	Miramar Res.
9-16-65	3	RSF	66	Chino Fisheries Base.

B. Sampling: Three collections of *Tilapia* hybrids were made following the introduction of fingerlings in Pond 2 on June 7, 1965. The first two collections were made by seining. The third and final collection was made by picking up the dead fish following the fish kill of September 8, 1965. Ninety-one fish were collected and measured. The mean total length was 6.6 inches.

An evaluation of this growth data will be made by Jim St. Amant. All other aspects of this study cannot be evaluated due to the effective elimination of the population.

Seining of ponds 3 and 4 following the September fish kill revealed a residual population of fish was present.

C. Fish Kills.

Two fish kills occurred during the summer of 1965; the first on August 25, 1965 followed by a second more severe kill on September 8, 1965.

Thousands of dead threadfin shad panfish, bass and channel catfish were removed following these kills from ponds 3 and 4. Pond 5 was not affected.

Several observations on this kill are recorded here.

1. Young-of-the-year and yearling bass were more numerous than ever before relative to the number of panfish. This is an indication at least that the introduction of sized bass may have resulted in reproductions and recruitment to the predator population.
2. Young-of-the-year panfish were not observed.
3. One yearling CCF was observed in Pond 3 indicating either survival of the 1965 CCF planting or successful spawning.
4. Several thousand postlarval threadfin shad were observed during the September kill indicating a very recent spawning. These fish were swimming at the surface and, apparently, were surviving the low-oxygen conditions by breaking the surface tension.

D. Recommendations.

1. The effects of this fish kill upon the species composition, growth and fishing success should be observed or measured during the next year to determine if the stocking of more predators would be desirable. Pond 5 will also be sampled to determine the extent of bass and shad reproduction.
2. The prevention of severe fish kills in the future deserves a high priority consideration. Feasible methods can probably be employed.
3. The movement of fish from one pond to another or the introduction of fish from other waters by other than DFG personnel should be prevented. Reports of such occurrences and evidence of this from our sampling have been found. The culprits are probably children who do not know any better. One youngster told me that he had planted a bullhead and some panfish in one of the ponds.

I hope that this report will be of assistance to all concerned wth the ponds at Santee.

Very truly yours,
Lee W. Miller
Fisheries Biologist II

LWM:en

cc: Ray Stoyer
Jim St. Amant, CFB
Region 5

APPENDIX B-3

RECORD OF FISH PLANTING BY DEPARTMENT OF FISH & GAME

LAKE 3

	Largemouth Bass	Channel Catfish	Threadfin Shad	Readear Sunfish
6 21-61			1,000	
3-27-62	118 (Florida)			
10-15-62		700		
6-16-64	100			
8-12-64			1,000	
10-26-64		1,280		
LAKE 4				
6-20-61	90 (Calif)			50
6-21-614			1,000	
12-15-61	62 (Calif.)	25		
10-15-62		300		
6-16-64	100			
8-12-64			1,000	
10-26-64		1,280		
LAKE 5				
4-12-65			750	
4-16-65	28			

a) Tilapia were planted (1120) in Lake 2 on 6-7-65

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
7- 9-62		S-1 Polio 1 ECHO 11 ECHO 12 Reovirus Adeno *	S-2 ECHO 12 Reovirus CoxsackieB-3 Adeno *					
7-23-62	S-3 ECHO 11 ECHO 12 Adeno Reovirus *	S-4 ECHO 11 ECHO 8 Adeno Reovirus *	S-5 Polio 1 Adeno CoxsackieB-3 Reovirus ECHO 12 *	S-6 Reovirus Polio 1 *	No S-7 *	No S-8 *	No S-9 *	No S-10 *
7-30-62	S-11 ECHO 7 ECHO 11 Reovirus *	S-12 Polio 1 ECHO 8 ECHO 12 Adeno Reovirus *	S-13 Polio 1 Reovirus Polio 3 *	S-14 ECHO 12 Reovirus *	No S-17 *	No S-18 *	No S-15 *	No S-16 *
8- 6-62	S-19 Reovirus Adeno ECHO 7 *	S-20 Reovirus Polio 3 ECHO 12 Adeno *	S-21 Polio 1 Reovirus Adeno ECHO 12 *	S-22 Reovirus *	No S-25 *	No S-26 *	No S-23 *	No S-24 *
8-13-62	S-27 Polio 1 Reovirus *	S-28 Polio 3 Polio 1 ECHO 12 *	S-29 Polio 1 Adeno *	S-30 Polio 1 Reovirus *	No S-33 *	No S-34 *	No S-31 *	No S-32 *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
8-23-62	37 ECHO 7 ECHO 11 ECHO 12 *	38 Polio 1 Reovirus ECHO 12 *	39 Polio 1 ECHO 11 CoxsackieB-1 *	40 Reovirus *	S-35 No *	S-36 No *	41 No *	42 No *
8-30-62	43 Polio 2 ECHO 7 ECHO 12 ECHO 11 *	44 Polio 3 ECHO 12 ECHO 8 *	45 ECHO 11 Polio 2 *	46 Reovirus ECHO 12 *	47 No *	48 ECHO 9 *	49 No *	50 No *
9-14-62	NS	51 Polio 1 ECHO 12 Polio 2 Polio 3 *	52 Polio 3 ECHO 12 Polio 1 *	53 Reovirus [illegible]CHO 8 *	54 No *	55 No *	56 No *	57 No *
9-20-62	NS	58 ECHO 12 Reovirus ECHO 8 *	59 Polio 3 ECHO 7 ECHO 11 *	60 Polio 1 Reovirus ECHO 3 ECHO 12 *	61 ECHO 8 *	62 No *	63 No *	64 No *
9-27-62	65 ECHO 7 ECHO 20 ECHO 11 ECHO 12 *	66 Polio 1 ECHO 12 CoxsackieB-3 *	67 Polio 1 ECHO 12 Polio 2 Polio 3 ECHO 19 *	68 Reovirus ECHO 12 *	69 No *	70 No *	71 No *	72 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
10-14-62	73 Polio 1 ECHO 7 ECHO 12 *	74 ECHO 12 CoxsackieB-1 Polio 3 *	75 Polio 1 Polio 3 ECHO 19 ECHO 12 *	76 Reovirus Polio 3 *	77 ECHO 8 Reovirus *	78 No *	79 No *	80 No *
10-11-62	81 ECHO 12 ECHO 7 ECHO 8 *	82 Polio 3 Reovirus ECHO 3 *	83 Polio 3 Polio 2 ECHO 12 ECHO 11 CxsckieA-18 *	84 ECHO 8 Reovirus ECHO 12 *	85 No *	86 No *	87 No *	88 No *
10-18-62	90 ECHO 7 Reovirus ECHO 12 ECHO 11 *	91 Reovirus ECHO 12 Polio 3 *	92 Polio 3 CoxsackieB-3 ECHO 12 ECHO 11 *	92 Reovirus ECHO 8 ECHO 3 *	94 No *	No	96 No *	97 No *
10-25-62	98 Polio 1 ECHO 12 Reovirus *	99 Polio 1 Reovirus ECHO 12 *	100 Polio 1 Polio 3 Reovirus CoxsackieB-3 CxsckieA-13 *	101 Cox B-3 Reovirus Polio 1 Unident. *	102 Reovirus *	103 No *	104 No *	105 No *
11-11-62	106 Polio 1 Reovirus ECHO 3 ECHO 8 *	107 Polio 1 CoxsackieB-3 Reovirus *	108 CoxsackieB-3 Polio 1 ECHO 7 Reovirus *	109 Polio 1 Reovirus *	110 Reovirus *	111 No *	112 No *	113 No *

Sabin Polio 1
Fed 10-21 & 28

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
11- 8-62	114 ECHO 12 Polio 1 Reovirus ECHO 19 *	115 Polio 1 ECHO 7 *	116 Polio 1 ECHO 12 Reovirus ECHO 7 *	117 CoxsackieB-3 Polio 1 Reovirus *	118 Polio 2 *	119 No *	120 No *	121 No *
11-15-62	122 Polio 1 ECHO 11 ECHO 19 Reovirus Cox B-5 *	123 CoxsackieB-3 Polio 1 ECHO 12 Reovirus *	124 CoxsackieB-3 Polio 1 ECHO 12 Reovirus *	125 CoxsackieB-1 CoxsackieB-3 Polio 1 Reovirus *	126 No *	127 No *	128 No *	129 No *
11-21-62	130 Polio 1 ECHO 12 Polio 2 ECHO 7 Reovirus *	131 ECHO 7 Polio 1 CoxsackieB-3 ECHO 11 *	132 CoxsackieB-3 Polio 1 ECHO 12 ECHO 7 *	133 CoxsackieB-3 Polio 1 Reovirus *	134 No *	135 No *	136 No *	137 No *
11-28-62	138 Polio 1 ECHO 19 Cox B-3 ECHO 7 ECHO 12 Reovirus *	139 Polio 1 Cox B-3 Cox A-18 ECHO 12 Reovirus Polio 2 Adeno *	140 CoxsackieB-3 Polio 1 Adeno ECHO 14 Polio 2 *	141 Polio 1 CoxsackieB-3 *	142 No *	143 No *	144 No *	145 No *
12- 5-62	146 Polio 2 Polio 1 Reovirus ECHO 12 ECHO 19 *	147 Polio 1 Polio 2 Cox B-3 Adeno *	148 Polio 1 Polio 2 ECHO 12 ECHO 7 Adeno *	149 Polio 1 Polio 2 Adeno *	150 No *	151 No *	152 No *	153 No *

Sabin Polio 2
Fed 12-2 & 9

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT
SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl²	Pond #1 After Cl²	Lake 4 Inlet	Lake 4 Outlet
12-12-62	154 Polio 1 Polio 2 Adeno Polio 3 Reovirus *	155 Polio 2 Polio 1 CoxsackieB-3 Adeno Polio 3 *	156 Polio 1 Polio 2 Polio 3 ECHO 7 *	157 Polio 2 Reovirus *	158 No *	159 No *	160 No *	161 No *
12-19-62	162 CoxsackieB-5 Polio 1 Polio 2 Adeno ECHO 12 *	163 Polio 2 Polio 3 CoxsackieB-1 Reovirus *	165 Polio 1 Polio 2 Polio 3 Adeno ECHO 12 Reovirus *	165 Polio 2 ECHO 7 Reovirus *	166 No *	167 No *	168 No *	169 No *
1- 9-63	170 Polio 1 Polio 2 Polio 3 *	171 Polio 2 Adeno *	172 Polio 1 Polio 2 Reovirus *	173 Polio 2 Adeno Reovirus ECHO 12 *	174 Polio 2 *	175 No *	176 No *	177 No *
1-16-63	178 Polio 1 Polio 2 Adeno Reovirus *	179 Polio 1 Polio 2 Adeno *	180 Adeno Polio 2 Reovirus *	181 Polio 2 Reovirus *	182 No *	183 No *	184 No *	185 No *
1-23-63	NS	186 Adeno Polio 1 Polio 2 *	187 Polio 1 Polio 2 Adeno *	188 Polio 2 Adeno Reovirus *	189 No *	190 No *	191 No *	192 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Sabin Polio 3
Fed 2-10

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
1-28-63	193 Polio 2 Adeno Reovirus *	194 Polio 1 Polio 2 Adeno Reovirus *	195 Polio 1 Polio 2 Reovirus *	196 Adeno Reovirus *	197 No *	198 Reovirus *	199 No *	200 No *
2- 4-63	201 Polio 2 *	202 Adeno Polio 2 Reovirus *	203 Polio 2 Adeno Reovirus *	204 Reovirus *	205 No *	206 Reovirus *	207 No *	208 No *
2-13-63	209 Polio 3 Reovirus Adeno Polio 1 *	210 Polio 3 Adeno Reovirus *	211 Polio 3 Polio 1 Reovirus *	212 Polio 3 Reovirus Adeno *	213 No *	214 No	215 No *	216 No *
2-18-63	217 Polio 1 Polio 3 Adeno Polio 2 Reovirus *	218 Polio 3 ECHO 7 Reovirus *	219 Polio 3 ECHO 7 Polio 1 *	220 Polio 3 Reovirus ECHO 7 *	221 No *		222 No *	223 No *
2-25-63	228 Polio 2 Polio 1 Polio 3 *	224 Polio 1 Polio 3 ECHO 11 Polio 2 *	225 Polio 3 *	226 Polio 2 Polio 3 Reovirus ECHO 11 *	227 No *	*	230 No *	229 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
3- 4-63		231 Polio 3 Adeno Polio 1 Unident. *	232 Polio 3 Adeno Reovirus *	233 Polio 2 Polio 3 Adeno Reovirus *	234 No *	235 No *	236 No *	237 No *
3-11-63		238 Adeno Polio 3 ECHO 21 *	239 Polio 3 Adeno Reovirus *	240 Polio 3 Adeno Polio 2 Reovirus *	241 Reovirus *	242 No *	243 No *	244 No *
3-18-63	245 Polio 3 Adeno Reovirus *	246 Polio 3 Polio 2 Reovirus *	247 Polio 3 Polio 2 Adeno Reovirus *	248 Polio 2 Adeno Reovirus *	249 No *	250 No *	251 No *	252 No *
4- 1-63	253 Polio 2 Polio 3 Adeno Polio 1 *	254 Adeno Polio 1 Polio 2 Reovirus *	255 Polio 1 Polio 3 Polio 2 Adeno Reovirus *	256 Reovirus *	257 No *	258 5A No *	259 No *	260 No *
4- 8-63		261 Polio 1 *	262 Adeno Polio 1 Polio 2 *	263 Polio 3 Reovirus *	264 No *	265 No *	266 No *	267 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Primary Effluent	Activated Sludge Effluent	Pond #1 Before Cl²	Pond #1 After Cl²	Lake 4 Inlet	Lake 4 Outlet
Unchlor. to perc. 4-19-63 4-22-63	*	268 Reovirus Adeno *	269 Reovirus Adeno Polio 2 *	270 Reovirus *	271 Reovirus *	272 No 5A *	273 No *	274 No *
5- 6-63	275 Polio 2 Reovirus *	276 Polio 3 Adeno *	277 Polio 1 Reovirus *	278 Polio 2 Reovirus *	279 No *	280 No *	281 No (7A) *	
5-20-63	282 Reovirus Polio 2 *				283 No *		284 No *	285 No *
6-11-63	286 Reovirus ECHO 7 Polio 2 Unident. *	287 Adeno Polio 1 *	288 Reovirus Adeno ECHO 19 *	289 Reovirus ECHO 20 ECHO 19 *	290 No *	291 No (5A) *	292 No *	293 No 7A *

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Rew Sewage San Diego	Raw Sewage Santee	Activated Sludge Effluent	Pond #1 Before Cl #4	Pond #1 Af. Cl^2 #5A Spec. Swab	Pond #4 Before Cl^2 #7	Lake 4 After Cl #7A	Lake 4 Outlet #8
6-24-63	294 Reovirus ECHO 12 Polio 3 *	295 Polio 1 ECHO 19 *	296 Polio 2 Polio 3 Adeno *	297 *	298 5A No *	299 No *	300 No *	301 No *
7- 8-63	302 ECHO 7 *	303 Reovirus Polio 3 ECHO 3 *	304 Adeno Reovirus *	305 *	306 5A No *	307 No *	308 No *	309 No *
7-22-63		310 Polio 1 Reovirus *		311 No *		312 No *		
8- 5-63		313 ECHO 7 Reovirus *		314 0/4 Neg. *	315 #4A Neg. *	316 *		317 *
8-19-63		318 Polio 2 ECHO 20 ECHO 19 ECHO 7 *		319 No *		320 No *		321 No *

* Completed

GPO 804-840-7

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Raw Sewage San Diego	Raw Sewage Santee	Activated Sludge Effluent	Pond #1 Before Cl #4	Pond #1 Before Cl 4A Spec. Swab	Pond #4 Before Cl² #7	Lake 4 Inlet Af. Cl #7A	Lake 4 Outlet #8
9-13-63		322 Polio 2 Reovirus ECHO 19 *		No 323 *	No 324 *	No 325 *		No 326 *
9-16-63		327 Adeno ECHO 7 *	Discarded 328 *	No 329 *	No 330 *	No 331 *	No 332 *	
9-30-63		333 Reovirus *		No 334 *	No 335 *	No 336 *		No 337 *
10-14-63		338 Reovirus ECHO 19 *	Discarded 339 *	No 340 *	Reovirus 343 *	No 341 *	No 342 *	
10-28-63		344 ECHO 7 Reovirus *		ECHO 19 345 *	No 346 *	No 347 *		No 348 *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent #3	Pond #1 Before Cl #4	Pond #1 Before Cl 4A Spec. Swab	Pond #4 Before Cl^2 #7	Lake 4 Inlet #7A	Lake 4 Outlet #8
11-18-63		349 ECHO 7 Reovirus *		350 No *	351 ECHO 7 *	352 Discard *		353 No *
12- 2-63	354-355 Algae from Tank Sed. No **	356 Polio 2 Adeno ECHO 7 *		357 No *			358 No *	359 No *
12-16-63	360 Act. Sl. Eff. Grab Reovirus *		361 No *	362 No *	363 No *	364 No *		365 No *
1- 6-64	366 Water No Bryozoan 2, 3, 4 No **		367 Reovirus *	368 Reovirus *	369 Reovirus *	370 No *		371 No *
1-20-64				372 No *	373 Reovirus *	374 No *		375 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent #3	Activated Sludge Effluent #3A	Pond #1 Before Cl^2 #4	Pond #4 After Cl^2 #7	Lake 4 Inlet #7A	Lake 4 Outlet #8
2- 3-64	376-379 Bass — No) (11-18-63) ****	384 Adeno *	385 Reovirus Adeno *	386 Polio 3 Reovirus *	387 No *	388 No *		389 No *
2-17-64	380-383 Bluegills—No ****	400 Adeno Reovirus *	401 Reovirus Adeno *	402 Adeno Reovirus *	403 No *	404 No *		405 No *
3- 2-64	390-392 Bass—No 393-394 Bluegills—No 395 Catfish—No ******	406 Reovirus Polio 2 Adeno *	407 Reovirus Adeno Polio 1 *	408 Reovirus Adeno *	409 No *	410		411 No *
3-16-64	396-399 Bluegills—No ****	412 Adeno *	413 Polio 3 *	414 Polio 2 *	415 No *	416 No *		417 No *
3-30-64		418 Adeno *	419 Adeno Polio 1 Reovirus *	420 Reovirus Polio 2 *	421 No *	422 No *		423 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent #3	Activated Sludge Effluent #3A	Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet #7	Lake 4 Outlet
4-13-64		424 Polio 1 ECHO 7 *	425 Adeno Polio 2 ECHO 7 *	426 Polio 2 *			427 No *	
4-27-64		428 Reovirus *	429 No *	430 Reovirus *	431 No		432 No *	433 No *
5-11-64		434 Polio 3 Adeno Polio 1 *	435 Adeno *	436 Reovirus *	437 No *		438 No *	
5-25-64		439 Polio 2 Adeno *	440 Adeno Polio 2 *	441 Adeno Reovirus *	442 No *		443 No *	
6- 8-64		444 Reovirus *	445 Reovirus *	446 ECHO 11 *	447 No *		448 No *	
6-22-64		449 Reovirus Adeno Polio 1 *	450 Adeno Reovirus *	451 Polio 2 Reovirus *	452 No *		453 No *	454 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY **Table (Continued)**

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent #3	Activated Sludge Effluent #3A Spec.	Pond #1 Before Cl_2	Lake 4 BCL #7	Lake 4 Inlet ACL #7A	Lake 4 Outlet
7-13-64		455 Reovirus Adeno *	456 Reo Adeno *	457 Reo Adeno *		458 No *		
7-27-64		459 Adeno Polio 3 Reovirus *	460 Reovirus *	461 Polio 2 Adeno Reo *	462 No *	463 No *		464 No *
8-10-64		465 Polio 2 Reo *	466 Reovirus *	467 Reovirus *	468 No *	469 No *		470 No *
8-24-64		471 Reo *	472 Reovirus *	473 Polio 2 Reo *	474 No *	475 No *		
9-14-64		476 Adeno Reovirus *	477 ECHO 7 *	478 Cox B-4 ECHO 7 Reovirus *	479 No *	480 No *		481 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent		Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
			#3	#3A Spec.				
9-28-64		482 No* Repeat Innoc. Reovirus *	483 Reovirus ECHO 19 *		484 Polio 2 *		485 No *	486 No *
10-13-64		487 Reovirus ECHO 19 Adeno *	488 Polio 2 Cox B-4 Adeno *	489 Polio 2 Cox B-2 *	490 No *		491 No *	492 No *
10-26-64		493 Reovirus *	494 Reovirus *	495 *	496 No *		497 No *	498 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent		Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
			#3	#3A Spec.				
11- 9-64		Polio 2 504 *	Polio 2 Reovirus 505 *	Reovirus 506 *	No 507 *		No 508 *	No 509 *
11-23-64		Reovirus 521 *	Reovirus ECHO 11 522 *	Reovirus Adeno 523 *	No 524 *		No 525 *	No 526 *
12- 7-64		Reovirus Adeno ECHO 11 ECHO 9 532 *	Reovirus ECHO 3 533 *	Reovirus Adeno 534 *	No 535 *		No 536 *	No 537 *
12-21-64		Reovirus 543 *	Reovirus ECHO 3 544 *	Reovirus Polio 2 ECHO 3 545 *			No 546 *	

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* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent		Pond #1 Before Cl^2	Pond #1 After Cl^2	Lake 4 Inlet	Lake 4 Outlet
			#3	#3A Spec.				
1- 4-65		553 Reovirus ECHO 7 Adeno *	554 Reovirus Adeno *	555 Reovirus Adeno *	556 No *		557 No *	558 No *
1-18-65		565 Reovirus Adeno *	566 Reovirus Adeno *	567 Reovirus Adeno *			568 Adeno	569 No *
1-29-65			573 Reovirus Adeno *		574 No *		575 No *	
2-15-65		576 Neg. Rpt. Inoc. Reovirus *			577 No *		578 No *	
2- 1-65		579 Reovirus *			580 Reovirus *		581 No *	

* Completed

Not completed as per S. Adv. Com.: 551, 552, 559, 560, 561, 562, 563, 564, 570, 571, 572 — Virus (P. 3) Seeding Test

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date Out	Misc.	Raw Sewage Santee	Activated Sludge Effluent		Pond #1 Before Cl²	Pond #1 After Cl²	Lake 4 Inlet	Lake 4 Outlet
			#3	#3A Spec.				
3-15-65		582 Reovirus *	583 Polio 2 *				584 No *	
3-29-65				585 Reovirus ECHO 19 *	586 ECHO 19 *			
4-12-65		587 Polio 3 Reovirus ECHO 11 *			588 No *	589 No *		
4-26-65		590 Reovirus *			591 No (Spec. Swab) Hannoun Type #4 *			
5- 3-65	596 Mesa Ave. (5-6-65) No *	592 Reovirus Adeno *			593 No *	594 No *		

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

	Special Dairy Samples				Percolate		Swim Area
Date Out	Mesa Road	Sycamore Canyon	Fanita Drive	Raw Sewage Santee	Before Cl^{2} (7b)	After Cl^{2} (7c)	Outlet (7d)
5-10-65		597 Sycamore Canyon Line Polio 1 *	598 Dairy Grab 599 Neg. *				
5-17-65 Pre-Swimming	596 (5-10-65) Reovirus			600 Reovirus Adeno *	601 No	602 Not Run	603 No *
5-21-65 Pre-Swimming					604 No *	605 Not Run	606 No (24 hr.) * No 607 *
5-24-65 Pre-Swimming				608 No (Reinoc.-Reovirus) *	609 No *	610 Not Run	611 No *
5-28-65 Pre-Swimming					612 Adeno Reovirus *	613 No *	614 No *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

	Special Dairy Samples				Percolate		Swim Area
Date Out	Mesa Road	Sycamore Canyon	Fanita Drive	Raw Sewage Santee	Before Cl^2 (7b)	After Cl^2 (7c)	Outlet (7d)
6- 1-65				Adeno 615 *	No 616 *	Not Run 617	No 618 *
6- 4-65 Swimmers					No 619 *	Not Run 620	No 621 *
6- 7-65 No Swimmers				Polio 2 622 *	No 623 *	Not Run 624	No 625 *
6-10-65 No Swimmers					No 626 *		No 627 *
6-14-65 No Swimmers					No 628 *	Not Run 629	No 630 *
6-21-65 Swimmers				Reovirus ECHO 7 631 *	No 632 *	Not Run 633	No 634 *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

	Special Dairy Samples				Percolate		Swim Area
Date	Mesa Road	Sycamore Canyon	Fanita Drive	Raw Sewage Santee	Before Cl^2 (7b)	After Cl^2 (7c)	Outlet (7d)
6-25-65 Swimnners					No 635 *	Not Run 636	No 637 *
6-28-65 Swimnners				Reovirus ECHO 7 638 *	No 639 *	Not Run 640	No 641 *
7- 2-65 Swimmers					No 642 *	Not Run 643	Broken 644
7- 6-65 No Swimmers				Reovirus Adeno 645 *	No **646 *		No **647 *
7- 9-65 Swimmers					No **648 *	Not Run **649	No **650 *

* Completed
**Potable Water Used

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

	Special Dairy Samples				Percolate		Swim Area
Date	Mesa Road	Sycamore Canyon	Fanita Drive	Raw Sewage Santee	Before Cl^2 (7b)	After Cl^2 (7c)	Outlet (7d)
7-12-65 Swimmers	656 † Reovirus *	655 † Reovirus *		651 Polio 2 Reovirus Adeno ECHO 7 *	**652 No *	**653 Not Run	**654 No *
7-16-65 Swimmers					**657 No *	**658 Not Run	**659 No *
7-19-65 Swimmers	665 † No *	664 † Reovirus *		660 Reovirus Polio 1 ECHO 19 *	661 No *	662 Not Run	663 No *
7-23-65 No Swimmers				666 Reovirus *	667 No *	668 Not Run	No
7-26-65 No Swimmers	637 Cox B-2 *	672 † Neg *	674 Polio 3 *	669 Reovirus ECHO 20 ECHO 7 ECHO 12 *	670 * No 7-30 675 No *	671 Not Run	No

* Completed
**Potable Water Used
† Tested Only for Reovirus

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY **Table (Continued)**

	Special Dairy Samples				Percolate		Swim Area
Date	Mesa Road	Sycamore Canyon	Fanita Drive	Raw Sewage Santee	Before Cl^2 (7b)	After Cl^2 (7c)	Outlet (7d)
8- 2-65 No Swimmers	680 No *	679 † No *	681 Polio 1 Polio 2 Polio 3 Non-Polio Entero *	676 ECHO 19 Reovirus Polio 2 ECHO 7 *	677 No *	678 Not Run	
8- 6-65 No Swimmers					682 No *	683 Not Run	
8- 9-65 No Swimmers	688 No *	687 † No *	689 No *	684 Adeno ECHO 11 Polio 1 Polio 2 ECHO 7 *	685 No *	686 Not Run	
8-13-65 No Swimmers					690 No *	691 Not Run	
8-16-65 No Swimmers				692 Polio 1 Reovirus Adeno Cox B-2 *	693 No *	694 Not Run	695 No *

* Completed
† Tested Only for Reovirus

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

	Special Dairy Samples				Percolate		Swim Area
Date	Mesa Road	Sycamore Canyon	Fanita Drive	Raw Sewage Santee	Before Cl^2 (7b)	After Cl^2 (7c)	Outlet (7d)
8-20-65 No Swimmers				696 Reovirus Cox A-9 Polio 2 ECHO 20 ECHO 11 Adeno *	No 697 *	Not Run 698	No 699 *
8-23-65 Swimmers				700 Reovirus *	No 701 *	Not Run 702	No 703 *
8-27-65 Swimmers					No 704 *	Not Run 705	No 706 *
8-30-65 Swimmers				707 Reovirus *	No 708 *	Not Run 709	No 710 *
9- 3-65 Swimmers					No 711 *	Not Run 712	No 713 *

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

	Special Dairy Samples				Percolate		Swim Area
Date	Mesa Road	Sycamore Canyon	Fanita Drive	Raw Sewage Santee	Before Cl^2 (7b)	After Cl^2 (7c)	Outlet (7d)
9- 7-65 Swimmers				714 Reovirus ECHO 19 Polio 2 *	No 715 *	Not Run 716	No 717 *
9-10-65 Swimmers					No 718 *	Not Run 719	No 720 *
Swim 9-12 9-13-65 Closed for Seas. No Swim.				721 Polio 3 ECHO 6 Unid. Agt. *	No 722 *	Not Run 723	No 724 *
9-17-65 No Swimmers				725 Reovirus ECHO 6 *	No 726 *	Not Run 727	
9-20-65 No Swimmers				728 ECHO 7 Polio 2 Reovirus Adeno *	No 729 *	Not Run 730	

* Completed

APPENDIX B-4 — VIRUS ISOLATIONS — SANTEE PROJECT

SAN DIEGO PUBLIC HEALTH LABORATORY

Table (Continued)

Date	Special Dairy Samples			Raw Sewage Santee	Percolate		Swim Area
	Mesa Road	Sycamore Canyon	Fanita Drive		Before Cl^2 (7b)	After Cl^2 (7c)	Outlet (7d)
9-27-65 No Swimmers				731 Reovirus Adeno *	No 732 *	Not Run 733	
10- 4-65				734 Polio 1 Reovirus ECHO 1 ECHO 19 *	No 735 *		
10-25-65							
11- 8-65							

* Completed

APPENDIX B-5

VIRUS RESULTS OF TEST WELL SAMPLING

SAMPLE DATE	SAMPLE SOURCE	SERIES NUMBER	IDENTIFICATION
11-10-64	200′ Well — Swab	510	Negative
	400′ Well — Swab	511	Negative
	200′ Well — Grab	512	No test-Swab (510) Negative
	400′ Well — Grab	513	No test-Swab (511) Negative
	Bed #6 — Grab	514	Negative
11-13-64	200′ Well — Swab	515	Negative
	400′ Well — Swab	516	Negative
	Bed #6 — Grab	517	Negative
11-15-64	200′ Well — Swab	518	Negative
	400′ Well — Swab	519	Negative
11-16-64	Bed #6 — Grab	520	Negative
11-23-64	1500′ Trench — Swab	527	Negative
	200′ Well — Swab	528	Negative
11-30-64	200′ Well — Swab	529	Negative
	1500′ Trench — Swab	530	Negative
	Chlorinated Contact Chamber Lake 5 — Swab	531	Negative
12- 7-64	200′ Well — Swab	538	Negative
	1500′ Trench — Swab	539	Negative
	Chlorinated Contact Chamber Lake 5 — Swab	540	Negative
12-14-64	1500′ Trench — Swab	541	Negative
12-21-64	200′ Well — Swab	547	Negative
	1500′ Trench — Swab	548	Negative
	Chlorinated Contact Chamber Lake 5 — Swab	549	Negative
12-28-64	200′ Well — Swab	550	Negative

Subsequent samples numbered 551, 552, 559-564 and 570-572 discarded on recommendation of Santee Advisory Committee.

APPENDIX B-6

SANTEE WATER RECLAMATION PROJECT

TOTAL VIRUSES ISOLATED BY MONTH SPECIMEN COLLECTED AND TYPE SANTEE RAW SEWAGE, PRIMARY EFFLUENT, ACTIVATED SLUDGE EFFLUENT AND ACTIVATED SLUDGE EFFLUENT (SPECIAL SWAB)

July 1, 1962 — October 4, 1965

Month Specimen Collected	Specimens	Total Virus Isol. [a]	Adenovirus	Reovirus	POLIO			COX-A		COX-B					ECHO										Unidentif.
					1	2	3	13	18	1	2	3	4	5	3	7	8	9	11	12	14	19	20	21	
7-62	8	30	5	8	5		1					2					2		2	5					
8-62	12	30	3	7	6	1	3			1							1		2	6					
9-62	9	29		4	5	2	4					1			1	1	2		1	7		1			
10-62 [b]	12	43		8	4	1	8	1	1	1		3			2	1	2		2	7		1			1
11-62	15	55	2	10	15	2			1	1		12				5			1	5	1				
12-62 [c]	9	36	5	4	6	9	4			1		2				3				2					
1-63	12	35	9	8	6	11														1					
2-63 [d]	12	34	4	9	3	4	9									3			2						
3-63	9	31	8	8	1	5	8																	1	
4-63	9	22	5	7	4	4	2																		
5-63	3	6	1	2	1	1	1																		
6-63	5	13	3	2	2	1	1															3	1		
7-63	3	7	1	3	1		1								1										
8-63	2	6		1		1										2						1	1		

[a] Duplicate isolations from a single specimen are excluded.
[b] Sabin polio 1 vaccine mass feeding 10-21-62 and 10-23-62.
[c] Sabin polio 2 vaccine mass feeding 12-2-62.
[d] Sabin polio 3 vaccine mass feeding 2-10-63.

SOURCE: Public Health Laboratory
San Diego Department of Public Health

APPENDIX B-6 (Continued)
SANTEE WATER RECLAMATION PROJECT
TOTAL VIRUSES ISOLATED BY MONTH SPECIMEN COLLECTED AND TYPE SANTEE RAW SEWAGE, PRIMARY EFFLUENT, ACTIVATED SLUDGE EFFLUENT AND ACTIVATED SLUDGE EFFLUENT (SPECIAL SWAB)

July 1, 1962 — October 4, 1965

Month Specimen Collected	Specimens	Total Virus Isol. [a]	Adenovirus	Reovirus	POLIO			COX-A		COX-B					ECHO										Unidentif.
					1	2	3	13	18	1	2	3	4	5	3	7	8	9	11	12	14	19	20	21	
9-63	3	6	1	2		1										1						1			
10-63	2	4		2												1						1			
11-63	1	2		1												1									
12-63	3	4	1	1		1																			
1-64	1	1		1																					
2-64	6	11	5	5			1																		
3-64	9	17	6	5	2	3	1																		
4-64	6	8	1	2	1	2										2									
5-64	6	11	5	2	1	2	1																		
6-64	6	10	2	5	1	1													1						

[a] Duplicate isolations from a single specimen are excluded.
[b] Sabin polio 1 vaccine mass feeding 10-21-62 and 10-23-62.
[c] Sabin polio 2 vaccine mass feeding 12-2-62.
[d] Sabin polio 3 vaccine mass feeding 2-10-63.

SOURCE: Public Health Laboratory
San Diego Department of Public Health

APPENDIX B-6 (Continued)

SANTEE WATER RECLAMATION PROJECT

TOTAL VIRUSES ISOLATED BY MONTH SPECIMEN COLLECTED AND TYPE SANTEE RAW SEWAGE, PRIMARY EFFLUENT, ACTIVATED SLUDGE EFFLUENT AND ACTIVATED SLUDGE EFFLUENT (SPECIAL SWAB)

July 1, 1962 — October 4, 1965

	Month Specimen Collected	Specimens	Total Virus Isol. [a]	Adenovirus	Reovirus	POLIO			COX-A		COX-B					ECHO										Unidentif.
						1	2	3	13	18	1	2	3	4	5	3	7	8	9	11	12	14	19	20	21	
	7-64	6	13	5	6		1	1																		
	8-64	6	8		6		2																			
	9-64	5	9	1	4									1			2						1			
	10-64	6	10	2	3		2					1		1									1			
	11-64	6	9	1	5		2													1						
	12-64	6	14	2	6		1									4				1						
	1-65	7	15	7	7												1									
	2-65	1	1		1																					
	3-65	4	5		3		1																1			
	4-65	2	4		2			1												1						
	5-65	3	4	2	2																					
	6-65	4	6	1	2		1										2									
Raw Only	7-65	5	14	2	5	1	1										2				1		1	1		
	8-65	6	21	3	5	2	3		1 (A-9)			1					2			2			1	1		
	9-65	5	14	2	4		2	1									1		2 (E-6)				1			1
	10-65	1	4		1	1										(E-1) 1							1			
	TOTAL	236	602	95	169	168	68	48	A9-1 1	2	4	2	20	2	0	E1-1 8	30	7	E6-2	16	34	1	15	4	1	2

SOURCE: Public Health Laboratory
San Diego Department of Public Health

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[a] Duplicate isolations from a single specimen are excluded.

[b] Sabin polio 1 vaccine mass feeding 10-21-62 and 10-23-62.

[c] Sabin polio 2 vaccine mass feeding 12-2-62.

[d] Sabin polio 2 vaccine mass feeding 2-10-63.

APPENDIX B-7

SANTEE WATER RECLAMATION PROJECT

PERCENT OF SPECIMENS POSITIVE BY VIRUS TYPE AND MONTH OF SPECIMEN COLLECTION SANTEE RAW SEWAGE, PRIMARY EFFLUENT, ACTIVATED SLUDGE EFFLUENT AND ACTIVATED SLUDGE EFFLUENT (SPECIAL SWAB)

July 1, 1962 — October 4, 1965

Month Specimen Collected	Specimens	Total Virus Isol. [a]	Adenovirus	Reovirus	PERCENT OF SPECIMENS POSITIVE FOR:																				Unidentif.
					POLIO			COX-A		COX-B					ECHO										
					1	2	3	13	18	1	2	3	4	5	3	7	8	9	11	12	14	19	20	21	
7-62	8	30	63	100	63		13					25					25		25	63					
8-62	12	30	25	58	50	8	25			8							8		17	50					
9-62	9	29		44	56	22	44					11			11	11	22		11	78		11			
10-62 [b]	12	43		67	33	8	67	8	8	8		25			17	8	17		17	58		8			8
11-62	15	55	13	67	100	13			7	7		80				33			7	33	7				
12-62 [c]	9	36	56	44	67	100	44			11		22				33				22					
1-63	12	35	75	67	50	92														8					
2-63 [d]	12	34	43	75	25	33	75									25			17						
3-63	9	31	89	89	11	56	89																	11	
4-63	9	22	56	78	44	44	22																		
5-63	3	6	33	67	33	33	33																		
6-63	5	13	60	40	40	20	20															60	20		
7-63	3	7	33	100	33		33								33										
8-63	2	6		50		50										100						50	50		

[a] Duplicate isolations from a single specimen are excluded.
[b] Sabin polio 1 vaccine mass feeding 10-21-62 and 10-28-62.
[c] Sabin polio 2 vaccine mass feeding 12-2-62 and 12-9-62.
[d] Sabin polio 3 vaccine mass feeding 2-10-63.

SOURCE: Public Health Laboratory
San Diego Department of Public Health

APPENDIX B-7 (Continued)

SANTEE WATER RECLAMATION PROJECT

PERCENT OF SPECIMENS POSITIVE BY VIRUS TYPE AND MONTH OF SPECIMEN COLLECTION SANTEE RAW SEWAGE, PRIMARY EFFLUENT, ACTIVATED SLUDGE EFFLUENT AND ACTIVATED SLUDGE EFFLUENT (SPECIAL SWAB)

July 1, 1962 — October 4, 1965

Month Specimen Collected	Specimens	Total Virus Isol. [a]	Adenovirus	Reovirus	PERCENT OF SPECIMENS POSITIVE FOR:																					
					POLIO			COX-A		COX-B					ECHO											Unidentif.
					1	2	3	13	18	1	2	3	4	5	3	7	8	9	11	12	14	19	20	21		
9-63	3	6	33	67		33										33						33				
10-63	2	4		100												50						50				
11-63	1	2		100												100										
12-63	3	4	33	33		33										33										
1-64	1	1		100																						
2-64	6	11	83	83			17																			
3-64	9	17	67	56	22	33	11																			
4-64	6	8	17	33	17	33										33										
5-64	6	11	83	33	17	33	17																			
6-64	6	10	33	83	17	17													17							

SOURCE: Public Health Laboratory
San Diego Department of Public Health

[a] Duplicate isolations from a single specimen are excluded.
[b] Sabin polio 1 vaccine mass feeding 10-21-62 and 10-23-62.
[c] Sabin polio 2 vaccine mass feeding 12-2-62 and 12-9-62.
[d] Sabin polio 3 vaccine mass feeding 2-10-63.

APPENDIX B-7 (Continued)
SANTEE WATER RECLAMATION PROJECT
PERCENT OF SPECIMENS POSITIVE BY VIRUS TYPE AND MONTH OF SPECIMEN COLLECTION SANTEE RAW SEWAGE, PRIMARY EFFLUENT, ACTIVATED SLUDGE EFFLUENT AND ACTIVATED SLUDGE EFFLUENT (SPECIAL SWAB)

July 1, 1962 — October 4, 1965

						PERCENT OF SPECIMENS POSITIVE FOR:																					
						POLIO			COX-A		COX-B					ECHO											
	Month Specimen Collected	Specimens	Total Virus Isol. [a]	Adenovirus	Reovirus	1	2	3	13	18	1	2	3	4	5	3	7	8	9	11	12	14	19	20	21	Unidentif.
	7-64	6	13	83	100		17	17																		
	8-64	6	8		100		33																			
	9-64	5	9	20	80									20			40						20			
	10-64	6	10	33	50		33					17		17									17			
	11-64	6	9	17	83		33													17						
	12-64	6	14	33	100		17									67				17						
	1-65	7	15	100	100												14									
	2-65	1	1		100																					
	3-65	4	5		75		25																25			
	4-65	2	4		100			50												50						
	5-65	3	4	67	67																					
	6-65	4	6	25	50		25										50									
Ray Only	7-65	5	14	40	100	20	20										40				20		20	20		
	8-65	6	21	50	83	33	50		17 (A-9)			17					33			33			17	17		
	9-65	5	14	40	80		40	20									20		40 (E-6)				20			20
	10-65	1	4		100	100										100 (E-1)							100			

SOURCE: Public Health Laboratory
San Diego Department of Public Health

[a] Duplicate isolations from a single specimen are excluded.

[b] Sabin polio 1 vaccine mass feeding 10-21-62 and 10-23-10-23-62.

[c] Sabin polio 2 vaccine mass feeding 12-2-62 and 12-9-62.

[d] Sabin polio 3 vaccine mass feeding 2-10-63.

APPENDIX B-8

QUARTERLY STUDY PERIOD BACTERIAL SUMMARY — CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH

Median MPN Summary for Conventional Treatment Systems; MPN/100 ml.

Coliform, Fecal Coliform, Fecal Streptococci in MPN/100 ml.

	1962				1963			1964
	Feb.	May	Aug.	Nov.	Apr.	July	Oct.	Jan.
Plant inlet								
Coli by 10^6	54	49	49	33	41	94	49	33
F. Coli %[a]	39	25	27	40	47	20	57	20
F. Strep x 10^6	1.3	0.79	13	0.79	3.0	2.2	1.6	1.7
Primary Effluent								
Coli by 10^6	54	79	64	49	33	56	49	41
F. Coli %	26	26	28	55	50	39	67	23
F. Strep x 10^6	0.79	1.7	1.1	0.79	2.4	3.5	3.0	1.3
Secondary Effluent								
Coli by 10^6	4.9	23	23	23	18	13	7.9	4.9
F. Coli %	52	41	40	51	40	38	62	67
F. Strep x 10^6	0.13	0.79	0.46	0.79	0.64	0.49	0.49	0.33
Pond Effluent (Before Chlorination)								
Coli x 10^3	310	780	180	790	330	68	490	330
F. Coli %	21	......	......	37	21	......	29	40
F. Strep x 10^3	0.79	7.0	1.3	9.2	1.3	0.17	10.2	11
Pond Effluent (After Chlorination)								
Coli	<2	4.5	39	4.5	4.5	127	180	2
F. Coli	<2	<2	<2	<2	<2	2	180	<2
F. Strep	<2	<2	<2	<2	<2	<2	2	<2

[a] Per cent Fecal Coli was obtained from actual counts in 1962 and from ratio of Median counts in 1963.

APPENDIX B-8 (Continued)

QUARTERLY STUDY PERIOD BACTERIAL SUMMARY — CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH

Median MPN Summary for Tertiary Treatment and Recreational Waters

Coliform, Fecal Coliform, Fecal Streptococci in MPN/100 ml.

	1962				1963			1964
	Feb	May	Aug	Nov	April	July	Oct	Jan
	Waste water before infiltration							
Coli	<2	4.5	39	4.5	4.5	68,000	490,000	130,000
F. Coli	<2	<2	<2	<2	<2	18,000	140,000	130,000
F. Strep	<2	<2	<2	<2	<2	170	10,200	11,000
	Ground Water 6.1[a]							
Coli	......	......	35,000	8,000	......	450	5,200	5,400
F. Coli	......	......	<180	200	......	<180	580	700
F. Strep	......	......	1,100	230	......	46	100	540
	Ground Water 6.2[a]							
Coli	......	......	22,000	5,200	1,700	18	<2	33
F. Coli	......	......	200	<180	<180	<18	<2	<2
F. Strep	......	......	200	280	490	<2	<2	<2
	Lake 4 Inlet							
Coli	1,300	7,900	4,900	4,900	1,700	3,300	3,500	1,400
F. Coli	78	<180	<180	200	<180	78	270	20
F. Strep	130	1,300	450	220	400	1,100	300	140
	Lake 4 Inlet (After Chlorination)							
Coli	......	......	......	......	......	4.5	2	2
F. Coli	......	......	......	......	......	<2	2	2
F. Strep	......	......	......	......	......	<2	2	2
	Lake 4 Outlet							
Coli	23	460	4,900	390	270	240	200	78
F. Coli	5	<18	20	<18	45	11	200	78
F. Strep	22	49	45	4.5	49	<18	36	13

[a] Obtained from ditch prior to and from pipe after April 1963.

APPENDIX B-9
BACTERIOLOGICAL RECORD — SAN DIEGO HEALTH DEPARTMENT LABORATORY
SANTEE WATER RECLAMATION RESEARCH PROJECT — By Quarters

BC = Coliform
FC = Fecal Coli
FS = Fecal Streptococci

MPN/100 ml   0 = <1.8   M = Millions

Sta. Qtr.	1 M BC	1 M FC	1 M FS	2 M BC	2 M FC	2 M FS	3 M BC	3 M FC	3 M FS	4 M BC	4 M FC	4 M FS	5 M BC	5 M FC	5 M FS
2-62	(336 Determinations)														
Min	33.0	6.8	.5	17.0	4.0	.5	1.3	.49	.04	.079	.002	0	0	0	0
Med	79.0	33.0	1.3	49.0	17.0	1.3	5.4	2.4	.2	.28	.049	700	0	0	0
Max	240.0	79.0	5.6	110.0	49.0	6.8	16.0	9.2	.9	1.6	.24	10000	2400+	2400+	10
3-62	(273 Determinations)														
Min	23.0	17.0	.7	33.0	11.0	1.0	3.5	.79	.08	.013	.002	<100	0	0	0
Med	130.0	33.0	1.2	79.0	33.0	1.5	5.4	2.4	.27	.11	.013	3900	28	0	0
Max	220.0	70.0	2.0	540.0	140.0	4.6	24+	5.4	2.4	.92	.35	54000	2400+	2400+	30
4-62	(231 Determinations)														
Min	6.8	4.5	.85	22.0	4.0	.12	.64	.79	.04	.11	.017	<100	0	0	0
Med	49.0	23.0	1.4	49.0	13.0	1.2	9.2	5.4	.30	.92	.54	3700	2	0	0
Max	350.0	130.0	1.9	95.0	23.0	2.3	24+	24.0	.35	2.4	1.6	112000	540	240	40
1-63	(255 Determinations)														
Min	21.0	4.5	.67	13.0	4.5	.69	.79	.045	0	.13	.022	0	13	0	0
Med	49.0	11.0	1.5	41.0	12.0	1.4	2.4	3.0	.07	.54	.17	1600	14-70	2	0
Max	350.0	23.0	5.8	79.0	33.0	2.0	16.0	5.4	.43	2.4+	.54	13000	2400+	2400+	4250

BACTERIOLOGICAL RECORD — SAN DIEGO LABORATORY
APPENDIX B-9 (Continued)
SANTEE WATER RECLAMATION RESEARCH PROJECT — By Quarters

MPN/100 ml 0 = <1.8 M = Millions

BC = Coliform
FC = Fecal Coli
FS = Fecal Streptococci

Sta.	7			8			5A			5B			7A		
Qtr.	BC	FC	FS	BC	FC	FS	BC	FC	FS	BC	FC	FS	BC	FC	FS
2-62	(336 Determinations)														
Min	110	0	0	34.0	0	0									
Med	1600	6.8	130	79.0	0	20									
Max	49000	70.0	4300	2400+	33.0	5700									
3-62	(273 Determinations)														
Min	130	2.0	0	49.0	0	0									
Med	1600	13.0	550	240.0	2.0	10									
Max	2400+	170.0	3000+	2400+	17.0	440									
4-62	(231 Determinations)														
Min	450	0	620	17.0	0	0									
Med	2400+	22.0	930	70.0	4.5	10									
Max	7900	200.0	1470	920.0	13.0	100									
1-63	(255 Determinations)														
Min	0	0	0	70.0	23.0	0	0	0		64	68.0	0			
Med	1300	0	360	230.0	240.0	110	2.0	0		64	68.0	0			
Max	54000	1100	4500	920.0	350.0	280	33.0	4.5		64	68.0	0			

BACTERIOLOGICAL RECORD — SAN DIEGO LABORATORY
APPENDIX B-9 (Continued)
SANTEE WATER RECLAMATION RESEARCH PROJECT — By Quarters

MPN/100 ml   0 = <1.8   M = Millions

BC = Coliform
FC = Fecal Coli
FS = Fecal Streptococci

	1 M BC	1 M FC	1 M FS	2 M BC	2 M FC	2 M FS	3 M BC	3 M FC	3 M FS	4 M BC	4 M FC	4 M FS	5 M BC	5 M FC	5 M FS
2-63	(267 Determinations)														
Min	4.5	2.0	0.5	21.0	2.0	1.0	3.5	.068	.3	.045	.017	700	NS	NS	NS
Med	49.0	7.8	1.4	49.0	7.8	1.9	16.0	3.5	.5	.35	.046	2600	NS	NS	NS
Max	110.0	33.0	3.4	130.0	22.0	5.0	24.0	16.0	.96	2.4+	1.6	12700	NS	NS	NS
3-63	(294 Determinations)														
Min	13.0	4.5	1.0	23.0	7.8	1.3	3.5	0.7	.19	.012	.0013	30	NS	NS	NS
Med	49.0	17.0	1.6	79.0	23.0	1.6	5.4	3.5	.25	.13	.02	2300	NS	NS	NS
Max	170.0	170.0	8.1	110.0	79.0	2.6	24+	9.2	.67	.24+	.24+	13000	NS	NS	NS
4-63	(301 Determinations)														
Min	23.0	<1.8	.86	NS	NS	NS	3.3	.02	.18	.084	.0006	800	NS	NS	NS
Med	49-79	16.0	1.1	NS	NS	NS	8.1	3.5	.46	.34	.022	4400	NS	NS	NS
Max	240.0	33.	2.8	NS	NS	NS	24+	9.2	.67	2.4+	2.4+	16000	NS	NS	NS
1-64	(300 Determinations)														
Min	2.0	1.8	0.8	NS	NS	NS	1.3	0.45	.01	.13	.018—	0	NS	NS	NS
Med	33.0	11.0	1.5	NS	NS	NS	3.3	3.3	.28	.23	0.13	4000	NS	NS	NS
Max	240.0	49.0	2.0	NS	NS	NS	17.0	7.9	2.3	1.4	.95	980000	NS	NS	NS
2-64	(300 Determinations)														
Min	7.8	2.0	.88	NS	NS	NS	2.8	0.7	.05	.11	.002	200	NS	NS	NS
Med	79.0	23.0	1.7	NS	NS	NS	9.2	2.4	.23	.34	.045	1300	NS	NS	NS
Max	240.0	130.0	8.6	NS	NS	NS	16.0	16.0	.45	.92	.54	7100	NS	NS	NS

* = x 10^{-6}

BACTERIOLOGICAL RECORD — SAN DIEGO LABORATORY
APPENDIX B-9 (Continued)
SANTEE WATER RECLAMATION RESEARCH PROJECT — By Quarters

MPN/100 ml 0 = <1.8 M = Millions

BC = Coliform
FC = Fecal Coli
FS = Fecal Streptococci

Sta.		7			8			5A			5B			7A	
Qtr.	BC	FC	FS	BC	FC	FS	BC	FC	FS	BC	FC	FS	BC	FC	FS
2-63	(267 Determinations)														
Min	130.0	0	240	33.0	0	0	0	0	0	2400+	4.5	0	0	0	0
Med	4600.0	1.0	1230	155.0	5.3	30	70.0	0	30	2400+	4.5	0	0	0	0
Max	54000	450.0	2650	1600.0	79.0	2100	540.0	13.0	70	2400+	4.5	0	350.0	17.0	70
3-63	(294 Determinations)														
Min	780.0	130.0	220	22.0	<1.8	0	NS	NS	NS	NS	NS	NS	0	0	0
Med	7900	200.0	670	170.0	23.0	30	NS	NS	NS	NS	NS	NS	2.0	<1.8	0
Max	160000	450.0	4300	2400+	46.0	900	NS	NS	NS	NS	NS	NS	4.5	4.5	20
4-63	(201 Determinations)														
Min	200.0	2.0	210	49.0	<1.8	0	<1.8	<1.8		NS	NS	NS	<1.8	<1.8	0
Med	2200.0	+180	620	195.0	7.8	20	<1.8	<1.8		NS	NS	NS	<1.8	<1.8	0
Max	35000	200.0	5260	930.0	49.0	2600	2400+	7.8		NS	NS	NS	7.8	<1.8	0
1-64	(300 Determinations)														
Min	400.0	180—	0	32.0	<1.8	0	<1.8	<1.8	0	450	40.0	10	1.8	1.8	0
Med	3300.0	180—	145	1600	17.0	230	49.0	<1.8	15.0	1300	180—	20	1.8	1.8	0
Max	35000	1700	2600	2400+	130.0	480	180—	180—	500	3300	450	180—	540	13.0	190
2-64	(300 Determinations)														
Min	<1.8	<1.8	0	17.0	<1.8	0	<1.8	<1.8	0	180	<180	0	0	<1.8	0
Med	930.0	200.0	530	110.0	7.8	20	<1.8	<1.8	0	2300	<180	25	<1.8	<1.8	0
Max	4900	2200	1800	1600	79.0	3000+	<1.8	<1.8	0	35000	450	60	4.5	<1.8	0

BACTERIOLOGICAL RECORD — SAN DIEGO LABORATORY
APPENDIX B-9 (Continued)
SANTEE WATER RECLAMATION RESEARCH PROJECT — By Quarters

MPN/100 ml 0 = <1.8 M = Millions

BC = Coliform
FC = Fecal Coli
FS = Fecal Streptococci

Sta. Qtr.	BC	1 M FC	FS	BC	3 M FC	FS	BS	4 M FC	FS *	BS	7 FC	FS
3-64	(252 Determinations)											
Min	2.0	<1.8	0.4	1.3	.49	.09	.13	.0045	100	400	180—	180
Med	49.0	28.0	1.6	5.5	3.0	.28	.155	.02	1800	4100	200	450
Max	130.0	79.0	3.9	24.0+	9.2	.61	1.7	.68	8700	7900	1300	1550
4-64	(243 Determinations)											
Min	13.0	4.5	0.4	1.3	.49	.03	.0045	.02	1600	180—	180—	0
Med	49.0	15.0	1.3	9.2	3.0	.19	.40	.13	5000	5200	180—	305
Max	540.0	70.0	2.6	24.0+	9.2	.36	9.2	.31	8900	92000	17000	790
1-65	(270 Determinations)											
Min	<1.8	<1.8	0	.49	.11	0	.13	.02	2000	180—	180—	40.0
Med	49.0	23.0	2.5	3.5	1.3	.16	.23	.13	7700	450	180—	130.0
Max	130.0	78.0	9.2	24.0+	9.2	.41	1.1	.79	34000	3300	180—	1210
2-65	(201 Determinations)											
Min	13.0	4.5	1.1	1.7	.33	.03	.018—	.018—	1300			
Med	79.0	23.0	2.0	3.5	.79	.19	.13	.045	4100			
Max	240.0	46.0	3.6	16.0	5.4	.32	2.4	.13	15600			
MEAN OF THE MINIMA	12.6	4.4	.66	2.0	.42	.08	.08	.01	500	247	11.0	126
MEDIAN OF THE MEDIANS	49.0	23.0	1.5	5.5	3.0	.25	.24	.045	3700	2400	180—	450
MEAN OF THE MAXIMA	246.2	76.2	4.6	21.0	10.4	.84	2.24	.80	98000	42117	2085	3119

* = x 10^{-6}

BACTERIOLOGICAL RECORD — SAN DIEGO LABORATORY
APPENDIX B-9 (Continued)
SANTEE WATER RECLAMATION RESEARCH PROJECT — By Quarters

MPN/100 ml   0 = <1.8   M = Millions

BC = Coliform
FC = Fecal Coli
FS = Fecal Streptococci

Sta.		7A			7B			7C			8	
Qtr.	BC	FC	FS	BC	FC	FS	BC	FC	FS	BC	FC	FS
3-64	(252 Determinations)											
Min	<1.8	<1.8	0							130	<1.8	0
Med	<1.8	<1.8	0							450	13	10
Max	<1.8	<1.8	0							2400+	350	380
4-64	(243 Determinations)											
Min	<1.8	<1.8	0							20	13	0
Med	<1.8	<1.8	0							225	23	20
Max	2.0	<1.8	0							2400+	49	140
1-65	(270 Determinations)											
Min	<1.8	<1.8	0							4.5	2.0	0
Med	<1.8	<1.8	0							49	31	20
Max	33	<1.8	10							220	170	100
2-65	(201 Determinations)											
Min				180—	20	190	<1.8	<1.8	0	2.0	<1.8	0
Med				2700	180—	1230	<1.8	<1.8	0	150	9.5	25
Max				92000	2300	11700	18—	18—	0	350	130	390
MEAN OF THE MINIMA												
	0	0	0	180—	20	190	<1.8	<1.8	0	36.9	3.0	0
MEDIAN OF THE MEDIANS												
	<1.8	<1.8	0	2700	180—	1230	<1.8	<1.8	0	170	9.5	20.0
MEAN OF THE MAXIMA												
	117.1	4.3	36.2	93000	2300	11700	18—	18—	0	1611+	115.0	1278

GPO 804-840-8

APPENDIX B-10

GENERA OF PHYTOPLANKTON OCCURRING IN THE OXIDATION POND AND LAKE 4 INLET AND OUTLET — February 1962 to August 1965

Group	Genus	Oxidation pond	Lake 4 Inlet	Lake 4 Outlet
Blue-Green	Agmenellum			x
	Anebaena			x
	Anacystis			x
	Gomphosphaeria			x
	Microcystis			x
	Oscillatoria	x	x	x
	Phormidium			x
	Raphidiopsis			x
Green	Actinastrum			x
	Ankistrodesmus	x		x
	Chlorella	x		x
	Chlorococcum	x		x
	Closterium	x	x	x
	Coelastrum	x		x
	Crucigenia	x		x
	Dictyosphaerium			x
	Elakatothrix			x
	Golenkinia			x
	Kirchneriella			x
	Lagerheimia	x		x
	Micractinium	x		x
	Oocystis	x		x
	Pediastrum			x
	Scenedesmus	x	x	x
	Schroederia	x		x
	Selenastrum	x		
	Sphaerocystis	x		x
	Spiregyra		x	
	Staurastrum			x
	Stichococcus			x
	Tetradesmus			x
	Tetraedron			x
	Uronema			x
Flagellates	Carteria	x		x
	Chlamydomonas	x	x	x
	Chlorogonium			x
	Chromulina			x
	Chroomonas			x
	Crystomonas			x
	Euglena	x		x
	Glenodinium	x		
	Hetromastix			x
	Lepocinclis	x		x

APPENDIX B-10 (Continued)

GENERA OF PHYTOPLANKTON OCCURRING IN THE OXIDATION POND AND LAKE 4 INLET AND OUTLET — February 1962 to August 1965

Group	Genus	Oxidation pond	Lake 4 Inlet	Lake 4 Outlet
Flagellates (cont.)	Nephroselmis			x
	Phacotus	x		x
	Phacus		x	x
	Polytomella	x		x
	Sphaerellopsis			x
	Trachelomonas		x	x
Diatoms	Cyclotella		x	x
	Diatoma			x
	Diploneis		x	
	Gomphonema		x	x
	Melosira			x
	Navicula	x	x	x
	Nitzschia	x	x	x
	Pennularia		x	
	Stephanodiscus			x
	Surirella		x	x
	Synedra	x	x	x

APPENDIX B-11

RECORD OF THE MOST ABUNDANT GENERA OF ALGAE IN THE OXIDATION POND — 1963

Date 1963	Genera	Pond 1 Outlet Avg count/ml	Pond 1 Outlet ppm/vol
Jan	Chlorella	24,500,000	29.6
	Selenastrum	271,000	4.1
	Oocystis	6,500	4.2
	Chlorococcum	4,800	5.2
Feb	Selenastrum	492,000	7.4
	Oocystis	28,600	22.0
	Chlorella	27,500	0.35
	Chlorococcum	6,200	5.2
Mar	Oocystis	115,000	91.8
	Euglena	22,000	234.0
	Chlorococcum	4,300	6.0
	Selenastrum	2,020	0.3

APPENDIX B-11 (Continued)

RECORD OF THE MOST ABUNDANT GENERA OF ALGAE IN THE OXIDATION POND — 1963

Date		Pond 1 Outlet	
1963	Genera	Avg count/ml	ppm/vol
Apr	Euglena	82,000	190.0
	Selenastrum	79,700	1.18
	Oocystis	60,900	34.9
	Chlamydomonas	16,900	1.9
May	Selenastrum	170,000	2.75
	Oocystis	167,000	111.0
	Chlorococcum	54,200	10.1
	Chlamydomonas	5,760	0.87
June	Oocystis	73,500	66.1
	Chlorococcum	20,900	15.3
	Euglena	468	13.1
	Nitzschia	468	0.3
July	Oocystis	122,000	101.0
	Chlorococcum	16,200	19.4
	Scenedesmus	2,500	2.7
	Chlorella	1,120	0.1
Aug	Oocystis	132,000	114.0
	Chlorococcum	18,500	67.0
	Chlorella	13,100	1.7
	Chlamydomonas	1,750	0.3
Sept	Oocystis	65,600	47.8
	Chlorococcum	36,500	14.6
	Euglena	2,640	61.7
	Scenedesmus	1,400	0.3
Oct	Micractinium	76,800	56.3
	Ankistrodesmus	9,500	0.7
	Chlorococcum	3,900	3.5
	Euglena	2,650	16.8
Nov	Selenastrum	101,000	1.5
	Micractinium	14,700	10.9
	Ankistrodesmus	14,100	1.9
	Chlorella	2,700	0.2
Dec	Selenastrum	240,000	3.8
	Ankistrodesmus	62,400	11.0
	Euglena	10,800	47.5
	Chlorella	1,500	0.2

APPENDIX B-12

DISSOLVED OXYGEN SUMMARY, (10 AM TO 3 PM)

Sampling period	Surface			At 4- to 5-ft depth		
	DO range, mg/liter	DO avg, mg/liter	Avg °F	DO range, mg/liter	DO avg, mg/liter	Avg °F
Pond 1						
May 1962	9 to 26	15	66	9.0 to 21	13	65
Aug	14 to 38	23	84	0 to 0	0.0	78
Nov	7.4 to 45	22	68	4.6 to 26	12	65
April 1963	11 to 22	16	55	6.6 to 8.4	7.5	64
July	12 to 38	22	80	0 to 4.2	1.0	76
Oct	0.4 to 14	8.7	70	0.8 to 1.8	1.3	70
Jan 1964	13 to 22	19	56	9.2 to 14	12	52
Pond 2 (Lake 2 in 1962 and 1965)						
April 1963	13 to 19	18	65	6.4 to 8.6	7.5	63
July	2.2 to 20	10	78	0.0 to 4.0	1.0	75
Oct	0 to 2.4	0.3	69	0 to 0	0.0	68
Jan 1964	7.2 to 15	12	53	6.0 to 100	7.0	52
Lake 4						
May 1962	5.8 to 19	12	66	8.6 to 12	11	66
Aug	4.4 to 11	7.8	79	4.4 to 7.8	5.9	77
Nov	7 to 17	13	63	8.0 to 12	10	61
April 1963	8.0 to 14	11	64	7.0 to 9.0	8.0	64
July	8.0 to 14	11	76	7.2 to 11	8.9	75
Oct	7.2 to 10	8.7	69	8.2 to 10	9.1	68
Jan 1964	10 to 13	12	50	11 to 12	12	50
Lake 3						
May 1962	3.4 to 10	6.7	67	4.6 to 9.4	6.8	66
Aug	8.0 to 15	11	81	6.8 to 8.0	9.8	78
Nov	7.0 to 10	9.2	64	7.0 to 8.8	7.4	62
April 1963	4.2 to 5.2	4.8	65	0.6 to 2.2	1.4	64
July	6.4 to 20	13	77	0.6 to 19	9.1	75
Oct	8.0 to 8.8	8.4	70	8.0	8.0	69
Jan 1964	12 to 15	13	51	11 to 14	13	51
Lake 2 (Pond 2 in 1963-64)						
May 1962	4.0 to 8.4	6.7	66	4.4 to 7.4	6.1	66
Aug	9.0 to 18	13	82	6.8 to 8.0	7.4	78
Nov	0.8 to 3.6	1.8	63	1.0 to 1.2	1.0	62

APPENDIX B-13

CHEMICAL AND PHYSICAL CHARACTERISTICS AT POND 1 — OUTLET

1963	ALKALINITY	NITROGEN (N)			PHOSPHATE (PO_4)		pH	°F	DO
	$CaCO_3$	NH_3	NO_3	Organic	Filtrd	Total			
6-12	280	20.6	0.86	6.1	21.0	24.0		76	22.2
6-18	260	15.0	0.47	4.3	10.5	16.5		82	13.0
6-25	256	12.5	0.42	7.1	3.0	6.6		83	30.6
7-2	268	14.4	0.46	2.5	6.1	12.3		79	18.4
7-9	250	12.3	0.79	5.9	10.2	14.0		84	30.6
7-17	256	11.8	0.34	9.17	5.1	18.5		84	26.2
7-23	244	13.4	0.3	8.6	3.5	19.0		88	30.4
7-31	244	12.8	0.42	9.8	4.6	14.8		84	37.2
8-7	252	14.6	0.18	11.8	9.5	16.0	8.4	80	21.0
8-13	244	13.8	0.42	7.1	8.0	17.2	8.55	83	19.9
8-20	232	13.1	0.29	10.0	4.5	16.0	8.55	84	24.7
8-27	256	16.2	0.32	8.4	7.75	16.5	8.35	82	28.8
9-10	272	16.9	0.13	6.27	17.0	26	7.9	80	11.0
9-19	288	19.7	0.07	8.7	15.0	28	7.7	80	10.6
9-25	412	21.5	0.04	5.5	28.0	42	7.05	80	0.6
10-3							8.45	80	25.2
10-10							7.0	78	17.4
10-16	265	15	0.12	5.3	25.0		7.3	70	13
10-24	292	15.0	0.12	5.0	38.0		8.0		
11-1							7.9	68	22
11-7							7.82	66	8.1
11-13	296	20.3	0.16	4.0	23.0	30	8.45	67	13.0
11-22	312	19.9	0.26	4.55	23.0	29	7.85	64	18.9
11-29							8.28	64	19.0
12-3	324	24.3	0.23	5.2	24.5	35			
12-10	340	24.0	0.13	5.6	22.0	28	8.45	60	28.8
12-16	340	24.1	0.26	6.1	25.0	26	8.94	58	27.3
12-23							8.4	60	20.8

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS AT POND 1 — OUTLET

1964	ALKA-LINITY	NITROGEN (N)			PHOSPHATE (PO_4)		pH	°F	DO
	$CaCO_3$	NH_3	NO_3	Organic	Ortho	Total			
1-14							8.5	53	21.2
1-22	296	24	0.12	7.1	21	35.0	8.6	58	20.4
1-29	308	19	0.16	13.0	17.0	28.0	8.82	66	13.3
No sampling February									
3-12	344	25	0.08	4.9	26	29	....	62	3.2
3-27							7.3	68	6.8
4-7	296	27	0.12	8.1	31	40	7.6	64	27.6
5-7	336	30	0.79	8.8	30	33	7.6	66	11.2
5-18	280	23.0	0.25	8.6	12.2	21.1	7.6	81	21.6
6-8	264	22	0.15	8.8	11.0	24	8.4	74	29.2
6-30	280	12	0.31	13.0	15.0	21	8.2	84	16
7-13	200	7.9	0.34	8.3	2.75	24	8.8	88	23.8
8-13	194	7.43	0.2	8.05	0.87	7.5	9.5	88	30.0
8-27	244	11.9	0.24	7.0	5.2	11.2	9.0	86	28.6
9-14	254	16.0	0.03	4.5	15.3	16.5	7.6	77	2.8
9-30	270	19.8	0.1	15.7	14.7	22.5	8.6	82	17.3
10-19	310	19.9	0.13	6.19	13.2	21.0	8.2	74	12.9
10-29	310	22.8	0.28	8.15	14.0	19.0	8.4	72	31.2
11-16	336	16.0	0.06	11.0	22.0	30.0	7.5	60	9.2
12-1	334	14.9	0.08	8.45	32.0	39.0	8.0	62	13.8
12-15	326	31.7	7.1	0.08	25.2	35.0	....	60	24.6

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS AT POND 1 — OUTLET

1965	NITROGEN (N)				PHOSPHATE (PO_4)			Carbon
	NH_3	NO_3	Organic	NO_2	Ortho	Total	Unfiltrd	Unfiltrd
2-9	28.5	0.2	0.2	3.7	32.7	31.6	32.7	31.6
2-25	33.5	0.1	0.1	8.1	40.2	39.6	27.5	44.0
3-10	31.8	0.2	0.2	7.4	37.2	42.3	20.5	50.0
4-7	30.3	0.2	0	9.2	37.5	38.4	27.5	44.5
4-15	22.8	1.3	0.4	9.8	29.6	31.6	26.5	49.5
5-6	19.0	0.2	0	10.6	14.7	19.2	25.0	65.5
5-20	16.0	0.5	0.1	10.9	5.4	15.6	24.5	73.0
6-3	23.0	0.1	0	9.0	19.3	25.9	25.5	60.0
6-17	22.5	0.2	0	14.8	12.4	26.3	27.0	70.5
7-15	20.4	0.3	0	9.4	10.2	26.1	29.0	61.0
7-28	21.8	0.2	0	10.3	10.8	22.5	22.0	53.0

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 4 — INLET

1963	ALKALINITY	NITROGEN (N)			PHOSPHATE (PO_4)				
	$CaCO_3$	NH_3	NO_3	Organic	Ortho	Total	pH	°F	DO
6-12	208	1.07	2.2	0.11	0.92	1.2		74	15.6
6-18	212	0.83	1.48	0.45	0.94	1.5		76	10.0
6-25	208	0.18	0.36	0.72	0.34	0.7		78	14.0
7-2	208	0.42	0.6	0.48	0.11	0.58		76	11.4
7-9	212	0.23	1.26	1.17	0.46	1.4		81	10.8
7-17	208	0.41	1.55	0.94	1.32	1.6		82	11.3
7-23	236	0.34	1.37	1.14	1.05	2.5		84	13.0
7-31	224	0.19	0.07	0.63	0.17	0.48	7.2	80	12.6
8-7	228	0.48	0.79	0.92	0.78	2.1	7.0	76	9.0
8-13	228	0.12	0.13	0.56	0.21	0.78	7.1	79	9.2
8-20	224	0.29	0.04	0.73	0.13	1.36	7.0	83	11.4
8-27	224	0.35	0	0	0.62	0.1	6.8	82	9.4
9-10	236	0.23	0.2	0.55	0.2	1.4	7.0	78	9.6
9-19	216	0.36	0.65	0.79	0.17	1.9	6.7	77	8.4
9-25	216	0.82	1.8	0.49	1.6	2.2	7.05	80	6.9
10-3							7.05	78	9.0
10-10							6.95	76	5.6
10-16	214	0.6	0.6	1.7	1.5		7.7	70	5.6
10-24	213	2.2	0.58	2.8	1.9		7.5		
11-1							7.1	70	5.8
11-13	220	0.39	1.03	0.74	0.69	1.15	7.2	68	6.3
11-22	220	0.68	1.55	0.87	1.22	1.6	7.1	64	7.4
11-29							7.1	63	9.4
12-3	228	0.43	1.26	0.82	1.6	3.4			
12-10	220	0.18	1.0	0.8	0.74	0.96	7.27	62	8.0
12-16	220	0.11	0.52	0.68	0.16	0.4	7.4	60	8.3
12-23	224	0.66	0.84	0.78	0.23	0.32	7.5	59	7.8

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 4 — INLET

1964	ALKA-LINITY	NITROGEN			PHOSPHATE		pH	°F	DO
	$CaCO_3$	NH_3	NO_3	Organic	Ortho	Total			
1-14							7.6	54	9.6
1-22	124	0.14	1.5	0.96	0.5	2.2	8.7	54	14.2
1-29	200	0.13	1.12	0.57	0.2	0.36	7.4	63	10.4
No sampling February									
3-12	212	0.15	0.77	0.89	0.21	0.36		59	10.2
3-27							7.3	63	9.6
4-7	232	0.21	0.97	0.64	2.0	2.4	7.6	63	14.4
5-7	230	0.74	1.31	1.00	3.2	3.7	7.5	68	12.6
5-18	224	0.06	0.15	0.13	0.42	0.53	7.4	82	13.4
6-9	216	0.09	0.01	0.70	0.02	0.09	8.0	77	14.1
6-30	188	0.06	0.03	0.78	0.02	0.23	8.1	88	16.8
7-13	198	0.07	0.04	0.83	0.0	0.13	7.8	88	17.0
8-13	164	0.16	0.22	0.82	0.0	0.09	8.4	90	14.0
8-27	162	0.08	5.3	1.2	0.05	0.1	8.6	88	16.5
9-14	162	0.08	1.37	0.71	0.13	0.15	8.5	82	16.4
9-30	166	0.15	0.29	0.58	0.16	0.3	8.5	82	13.0
10-19	218	0.17	0.12	0.61	0.48	0.61	7.4	77	0.0
10-29	228	0.14	0.03	0.63	0.98	1.2	7.6	72	10.4
11-16	208	0.14	0.29	0.29	0.28	0.59	8.0	62	14.0
12-1	194	0.09	2.24	0.85	0.32	0.87	7.7	63	16.8
12-15	190	0.08	0.2	2.4	0.45	0.49		60	16.2

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 4 — INLET

1965	NITROGEN				PHOSPHATE		Organic	Carbon	°F	DO
	NH_3	NO_3	NO_2	Organic	Filtrd	Unfiltrd	Filtrd	Unfiltrd		
2-10	2.4	1.6	0.1	0.6	7.3	7.7	10.5	10.5	62	14.0
2-18	2.8	2.0	0.2	0.8	9.3	9.4	11.0	11.0	66	10.4
2-25	1.7	3.0	0.3	1.0	11.4	12.6	11.4	12.0	60	23.6
3-11	1.8	3.2	0.2	1.1	10.2	10.8	12.5	13.5	....	....
4-16	0.1	3.8	0.0	1.5	2.1	2.5	10.5	13.0	....	....
5-6	0.1	0.0	0.0	2.2	1.3	3.2	10.5	22.0	72	20.4
5-20	0.1	0.1	0.0	0.9	1.4	1.7	9.0	11.0	76	13.0
6-3	1.4	0.0	0.0	1.0	6.6	6.8	8.5	8.5	....	....
6-17	0.0	0.0	0.0	1.5	1.9	2.2	10.0	15.0	....	....
7-15	0.0	0.0	0.0	1.4	2.2	2.5	9.0	13.5	80	10.4
7-28	0.1	0.0	0.0	1.5	2.4	4.3	11.0	12.5	78	13.0

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 4 — OUTLET

1962	°F	D.O.	Algae		1963	°F	D.O.	Algae	
			1000/ml	ppm				1000/ml	ppm
10-9	74	11.4	28	20.3	1-16	52	24.4	103	68.9
10-16	72	8.0	12	26.4	2-5	66	30.8	183	152.2
10-23	71	14.3	45	55.8	2-12	64	29.4	198	161.1
11-6	68	13.2	38	5.7	2-20	64	19.4	43	17.7
11-3	64	9.6	62	6.3	2-25	64	1.8	8	2.5
11-20	60	10.4	14	4.9	3-6	66	30.2	60	89.0
11-27	64	21.6	179	44.8	3-13	68	17.8	16	28.6
12-4	62	26.8	290	72.3	3-18	66	16.6	6	1.4
12-10	59	16.8	64	22.2	3-27	70	12.8	35	11.7
12-26	56	15.8	80	103.6	4-3	70	15.6	24	4.2
					4-10	74	13.8	7	0.9
					4-17	66	6.8	5	0.6
					4-25	73	11.2	19	4.8
					5-1	76	9.6	12	4.5
					5-7	80	7.4	12	12.3
					5-13	....	....	8	2.3
					5-28	....	....	9	6.0

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 4 — OUTLET

1963	Alkalinity	Nitrogen			Phosphate					Algae	
	$CaCO_3$	NH_3	NO_3	Organic	Ortho	Total	pH	°F	DO	10^3/ml	ppm
6-12	228	0.3	0	0.52	0.74	5.0		74	13.8	19	2.5
6-18	224	0.68	0	0.95	0.66	3.2		80	14.4	37	5.6
6-25	228	0.35	0.12	0.77	0.64	2.9		80	14.8	55	9.1
7-2	230	0.3	0	0.81	0.68	1.7		80	11.8	101	10.6
7-17	200	0.14	0.11	1.43	0.56	1.4		85	15.8	186	14.4
7-23	224	0.12	0.04	1.02	0.69	2.9		84	13.3	49	21.8
7-31	212	0.08	0.03	1.04	0.62	1.1	8.6	83	12.6	95	9.6
8-7	240	0.12	0.07	0.76	0.55	1.4	8.5	80	9	60	7.2
8-13	228	0.17	0.14	0.73	0.6	2.1	8.6	84	11	41	5.5
8-20	244	0.06	0.02	0.98	0.6	5.0	8.3	84	11.7	48	10.5
9-10	240	0.18	0	0.96	0.56	0.9	8.3	82	11.2	13	2.0
9-19	240	0.11	0.06	0.91	0.62	0.96	8.0	78	9.8	33	5.2
9-25	240	0.03	0	0.55	0.3	1.12	8.6	82	14.4	106	10.5
8-27	244	0.15	0.0	1.0	0.58	2.0	8.2	84	12	62	11.9
10-3							8.35	79	12.6	299	13.9
10-10							8.6	78	15.4	232	15.3
10-16	229	0	0.08	1.7	1.0		8.6	71	7.5	180	13.1
10-24	222	0	0.02	2.8	0.8		8.5	70	8.8	121	14.5
11-1							8.6	68	10.2	77	10.3
11-7							8.58	68	12.2	74	9.1
11-13	228	0.31	0.28	1.34	0.42	0.75	8.5	67	14.9	61	7.6
11-22	[illegible]	0.11	0.25	1.33	0.59	1.6	8.3	62	13.8	103	12.8
11-29							8.58	63	18.8		
12-3	[illegible]	0.1	0.17	1.68	0.36	1.9				74	4.6
12-10	[illegible]	0.08	0.04	1.2	0.23	0.69	8.5	56	14.8	106	9.0
12-16	224	0.03	0.04	1.2	0.16	0.62	8.65	55	15.8	59	8.0
12-23	204	0.25	0.02	0.99	0.15	0.26	8.95			45	8.0

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 4 — OUTLET

1964	Alkalinity	Nitrogen			Phosphate					Algae	
	$CaCO_3$	NH_3	NO_3	Organic	Ortho	Total	pH	°F	DO	1000/ml	ppm
1-14							8.52	50	14.4	15	2.1
1-22	204	0.04	.12	1.05	0.0	0.66	8.7	54	14.2	19	2.7
1-29	210	0.02	.10	1.6	0.0	0.32	8.7	61	17.8	12	1.4
No sampling February											
3-12	212	0.02	0.0	1.28	0.0	0.23	....	62	17.0	147	8.9
3-27	....	....	....	....	....	....	8.43	68	16.0	39	2.5
4-7	204	0.08	0.03	1.12	0.42	1.06	8.32	68	20.8	215	17.9
5-7	216	0.06	0.02	1.02	1.18	1.4	8.5	64	12.8	1	2.6
5-18	232	0.06	0.27	0.89	1.16	1.32	1.9	78	14.0	33	3.8
6-9	232	0.09	0.07	1.02	0.79	0.94	9.0	72	14.0	37	3.8
6-30	200	0.06	0.03	0.99	0.26	0.59	8.6	83	13.8	21	2.9
7-13	176	0.08	0.02	0.89	0.01	0.3	8.3	85	14.0	....	....
8-13	136	0.13	0.02	1.26	0.00	0.21	9.0	84	15.8	90	53.7
8-27	140	0.08	0.09	1.7	0.01	0.25	9.2	82	13.2	11	19.9
9-14	194	0.16	0.39	1.37	0.01	0.23	9.2	78	14.0	....	....
9-30	144	0.23	0.07	1.21	0.0	0.11	8.9	78	13.2	....	....
10-19	152	0.04	0.05	0.83	0.03	0.21	8.7	74	10.4	25	4.5
10-29	164	0.01	0.00	1.24	0.05	0.13	8.5	70	13.4	....	....
11-16	170	0.12	0.02	0.8	0.0	0.16	8.5	58	10.6	29	5.6
12-1	176	0.07	0.04	1.4	0.01	0.15	8.3	58	11.4	16	3.1
12-15	178	0.13	0.34	0.17	0.03	0.13	....	54	12.4	11	2.4

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 4 — OUTLET

	Nitrogen				Phosphate						Algae	
1965	NH_3	NO_3	NO^2	Organic	Filtered	Unfiltered	Organic Filtered	Carbon Unfiltered	°F	DO	1000/ml	ppm
2-10	0.3	0.2	0.1	0.7	0.5	0.6	10.5	19.0	60	11.6	3	1.3
2-18	0.3	0.3	0.0	0.7	1.4	1.5	10.5	12.0	62	9.6	1	.008
2-25	0.2	0.1	0.0	1.8	1.7	2.1	10.5	16.2	59	12.0	293	30.2
3-11	0.1	0.1	0.0	1.4	1.9	2.1	15.5	16.3	....	....	118	6.7
4-8	0.6	0.6	0.0	1.4	2.4	2.5	13.5	14.1	62	13.4	23	7.0
4-16	0.2	0.0	0.0	1.3	1.5	1.8	13.5	15.8	....	....	28	35.1
5-3	....	....	....	....	....	....	....	....	....	....	180	152.8
5-6	0.1	0.0	0.0	1.7	0.7	1.1	14.0	22.0	72	14.0	53	17.7
5-20	0.1	0.0	0.0	1.4	1.0	0.6	19.5	17.9	78	13.0	84	23.1
6-3	0.2	0.0	0.0	1.6	1.6	1.7	16.0	21.2	....	....	263	54.9
6-17	0.5	0.0	0.0	2.3	0.4	1.8	18.5	34.4	....	....	....	....
7-15	0.0	0.0	0.0	2.6	0.4	1.2	19.5	63.8	81	12.4	118	71.9
7-28	0.1	0.0	0.0	5.4	0.6	1.2	16.0	44.8	80	15.2	145	171.4
8-10	1.62	0.03	....	7.5	0.66	2.0	....	....	84	0.00	27	62.2
8-19	....	....	....	....	....	....	....	36.8	82	8.4	93	63
9-7	5.5	0.58	....	6.0	1.7	0.6	....	....	78	0.0	20	22.3

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 3 — OUTLET

	Alka-linity	Nitrogen			Phosphate				
1963	$CaCO_3$	NH_3	NO_3	Organic	Ortho	Total	pH	°F	DO
6-12	248	0.32	0.04	1.51	0.74	1.6		74	11
6-18	248	0.73	0.04	0.19	0.84	1.7		80	12.6
6-25	248	0.22	0.09	0.45	0.53	1.5		80	12
7-2	220	0.45	0.1	1.15	0.25	1.3		80	14
7-9	150	0.11	0.04	3.1	0.06	2.5		81	24.4
7-17	132	0.74	0.16	2.84	0.11	0.98		83	11.6
7-23	140	0.17	0	2.17	0.05	0.69		83	14.3
7-31	148	0.23	0.4	1.86	0.32	1.2	9.1	82	17.4
8-7	152	0.26	0	1.63	0.05	1.02	8.9	80	9.1
8-13	156	0.08	0.13	1.42	0.03	1.2	9.0	83	12
8-20	156	0.14	0.03	1.83	0.05	1.28	8.65	84	12.6
8-27	168	1.19	0	1.77	0.05	0.66	8.6	84	14.4
9-10	172	0.13	0	1.33	0.1	0.82	8.6	82	11.6
9-19	176	0.2	0.09	1.65	0.06	0.61	8.35	78	12.2
9-25	176	0.05	0.04	1.3	0.03	1.4	8.75	82	12
10-3							8.5	80	10.8
10-10							8.55	78	10.6
10-16							8.4	71	8.5
10-24									
11-1							8.8	68	10.2
11-7							8.8	68	12.5
11-13	200	0.16	0.02	1.15	0.46	0.96	9.1	65	13.7
11-22	196	0.11	0.07	1.67	0.12	1.9	8.7	60	14.8
11-29							9.0	60	16.4
12-3	204	0.04	0	1.66	0.09	1.8			
12-10	205	0.14	0.12	1.4	0.03	0.36	8.7	56	15.3
12-16	206	0.02	0.04	1.59	0.4	....	8.9	55	15.8
12-23							9.1	55	15.4

APPENDIX B-13 (Continued)

CHEMICAL AND PHYSICAL CHARACTERISTICS OF LAKE 3 — OUTLET

	Alkalinity	Nitrogen			Phosphate				
1964	$CaCO_3$	NH_3	NO_3	Organic	Ortho	Total	pH	°F	DO
1-14							8.9	50	14.2
1-22	192	0.08	0.02	1.17	0.0	0.42	8.8	53	12.4
1-29	190	0.01	0.02	1.37	0.0	0.21	8.8	60	15.4
No sampling February									
3-12	188	0.05	0.0	1.39	0.0	0.18	....	61	15.8
3-27	....	....	....	....	....	....	8.8	63	17.4
4-7	172	0.25	0.03	1.47	0.0	0.4	8.5	68	18.8
5-7	154	0.09	0.04	2.42	0.01	0.90	8.8	63	11.0
5-18	136	0.03	0.36	7.82	0.00	0.61	8.8	78	22.2
6-9	112	0.31	0.07	4.1	0.01	0.57	9.32	70	9.4
6-30	100	0.07	0.03	4.1	0.01	0.46	9.3	84	13.6
7-13	118	0.08	0.03	4.34	0.0	0.4	9.2	86	16.2
8-13	138	0.22	0.07	3.00	0.0	0.23	9.2	83	13.0
8-27	130	0.03	0.07	3.1	0.01	0.3	9.7	81	15.0
9-14	124	0.09	0.08	3.5	0.01	0.4	9.9	77	15.2
9-30	110	0.14	0.03	3.24	0.03	0.32	9.9	78	14.8
10-19	112	0.04	0.09	2.59	0.00	0.25	9.7	72	16.8
10-29	124	0.09	0.07	3.23	0.00	0.36	9.6	70	14.2
11-16	122	0.12	0.12	1.33	0.03	0.3	9.3	57	8.6
12-1	128	0.06	0.07	1.45	0.09	0.25	8.7	57	9.4
12-15	134	0.09	0.55	0.07	0.01	0.3	....	54	9.2

APPENDIX B-13 (Continued)

TEMPERATURE AT THREE STATIONS — LAKE NO. 4*

1962	B-1	B-1b	B-2	B-2m	B-2b	B-3	B-3m	B-3b
10-9	72	72	74		74	74		74
10-16	72	72	72		71	72		70
10-23	71	70	72		70	71		70
11-6	69	68	68		64	68		64
11-13	64	64	64		64	64		64
11-20	62	60	60		59	60		58
11-27	64	62	63		60	64		60
12-10	60	60	59		58	59		58
12-26	58	58	57		56	58		56
1963								
1-16	52	52	51	50	48	51	51	48
2-5	62	63	64		64	66		61
2-12	61	61	63	63	58	64	61	58
2-20	64	64	64	64	61	64	64	61
2-26	68	68	66	66	64	68	66	64
3-6	64	62	65	62	60	66	63	60
3-13	66	66	68	66	62	68	66	62
3-19	62	61	64	62	60	66	64	60
3-27	70	68	70		64	70		64
4-3	67	66	70	68	66	70	68	63
4-10	71	70	72	69	66	74	72	66
4-17	66	65	66	65	64	66	65	66
4-25	70	70	72	71	67	73	72	66
5-1	77	76	76	74	72	76	72	70
5-7	80	79	80	78	74	80	76	72
6-12	73	73	74	73	69	73	72	68
6-18	82	82	81	81	73	80	79	69
6-25	81	81	80	79	73	80	75	73
7-2	80	80	82	82	77	82	82	76
7-9	83	83	83	82	78	82	80	78
7-17	84	84	84	83	79	85	84	79
7-23	84	84	84	84	82	84	82	78
7-31	84	83	84	82	79	83	83	80
8-7	80	80	81	80	79	82	82	78
8-13	84	84	85	84	80	86	80	80
8-20	84	84	84	84	81	84	84	80
8-27	82	82	84	83	80	84	83	79

APPENDIX B-13 (Continued)

TEMPERATURE AT THREE STATIONS — LAKE NO. 4*

1963 (cont.)

	B-1	B-1b	B-2	B-2m	B-2b	B-3	B-3m	B-3b
9-10	80	80	82	82	81	82	81	78
9-19	76	77	77	76	75	78	76	75
9-25	84	83	83	82	78	83	82	78
10-3	80	80	80	80	78	80	79	78
10-10	76	76	78	77	74	78	76	74
10-16	71	70	71	70	70	71	70	70
11-1	68	68	68	68	68	68	68	68
11-7	66	66	68	66	66	68	68	68
11-13	66	65	66	66	65	68	66	65
11-22	60	59	62	61	58	62	60	59
11-29	60	58	61	61	58	63	62	58
12-10	58	56	56	56	56	56	56	54
12-16	54	54	56	54	54	57	54	53
12-23	56	56	56	54	52	55	54	54

Sampling Depths, ft

B-1, 2, 3 — 1
B-1b — 2
B-2m — 3
B-2b — 6
B-3m — 4
B-3b — 8

APPENDIX B-13 (Continued)
DISSOLVED OXYGEN AT THREE STATIONS — LAKE NO. 4*

1962	B-1	B-1b	B-2	B-2m	B-2b	B-3	B-3m	B-3b
10-9	14.2	14.4	12.2		9.4	11.4		7.8
10-16	8.4	8.1	8.0		7.8	8.0		7.2
10-23	12.4	12.4	14.2		6.2	14.3		6.3
11-6	21.2	14.2	14.2		10.0	13.2		9.0
11-13	11.0	10.6	11.0		9.6	9.6		9.0
11-20	11.4	11.4	11.4	10.8	10.6	10.4	10.4	8.2
11-27	20.9	18.2	21.0	19.4	11.6	21.6	22.3	8.8
12-10	16.2	17.6	14.2	14.6	11.7	16.8	15.6	14.0
12-26	23.8	24.1	20.0	18.4	15.2	2.0	18.0	15.8
1963								
1-16	24.6	24.4	24.4	23.6	21.4	24.4	21.4	17.4
2-5	25.0	25.6	34.0	29.0	18.6	30.8	28.4	18.2
2-12	24.2	23.0	26.6	25.6	22.0	29.4	25.0	15.2
2-20	19.2	18.6	20.2	19.6	16.4	19.4	19.4	13.4
2-25	2.6	2.8	2.6	2.8	1.6	2.4	2.8	1.8
3-6	30.8	29.1	29.1	27.8	25.7	30.2	28.3	24.0
3-13	18.4	17.6	18.6	....	12.2	17.8	18.6	21.4
3-19	15.6	14.8	17.4	16.4	9.6	16.6	17.6	5.4
3-27	12.2	11.4	12.8	....	4.0	12.8	....	4.6
4-3	14.6	15.6	15.4	16.0	11.2	15.6	16.2	7.4
4-10	12.8	12.7	13.4	12.0	11.5	13.8	13.4	7.8
4-17	6.8	6.6	6.8	6.8	6.6	6.8	7.2	7.1
4-25	10.8	11.2	10.8	11.0	9.3	11.2	10.4	8.3
5-1	9.2	9.2	9.4	9.4	7.6	9.6	9.0	5.4
5-7	7.1	7.1	7.4	7.3	5.2	7.4	7.1	2.6
6-12	13.0	13.0	15.2	14.8	6.8	14.2	13.1	6.6
6-18	13.6	13.6	13.8	13.4	6.8	14.8	14.4	6.4
6-25	14.2	14.0	14.6	13.6	11.8	14.7	13.7	5.3
7-2	12.0	12.0	13.0	13.6	7.8	12.8	12.8	8.8
7-9	13.0	13.0	14.2	13.6	8.6	14.2	12.2	6.4
7-17	15.0	15.5	15.6	16.2	10.8	16.8	16.6	10.0
7-23	12.2	11.8	12.2	12.0	9.4	12.2	12.9	4.4
7-31	12.2	10.2	11.2	11.4	7.2	11.2	11.6	3.5
8-7	9.1	9.2	9.3	8.9	7.6	9.6	8.8	3.2
8-13	10.8	10.8	10.8	11.0	8.0	10.0	10.5	4.8
8-20	10.1	10.6	10.4	10.3	9.2	10.4	9.8	8.4
8-27	10.8	10.8	10.8	10.6	8.8	10.7	10.7	8.2

APPENDIX B-13 (Continued)

DISSOLVED OXYGEN AT THREE STATIONS — LAKE NO. 4*

1963 (cont.)

	B-1	B-1b	B-2	B-2m	B-2b	B-3	B-3m	B-3b
9-10	10.2	10.6	10.9	10.6	10.2	10.6	10.3	2.7
9-19	10.1	9.6	9.5	9.4	5.8	9.2	9.4	6.6
9-25	13.5	14.2	14.3	14.6	10.2	14.2	12.7	6.6
10-3	14.6	14.8	13.8	13.6	8.4	12.1	10.4	7.8
10-10	16.2	14.8	16.5	16.1	9.6	16.8	13.1	8.5
10-16								
11-1	12.1	12.0	12.2	12.0	10.8	11.6	11.3	9.0
11-7	12.7	12.4	13.2	12.7	11.0	13.0	12.8	9.6
11-13	13.9	13.8	16.8	16.2	13.3	16.4	17.0	12.9
11-22	12.8	12.2	13.1	13.5	10.7	13.6	13.7	11.1
11-29	20.2	19.8	22.0	22.8	17.2	22.6	23.8	17.0
12-10	17.7	17.8	16.8	16.5	15.7	17.1	16.0	14.8
12-16	17.4	17.3	17.0	17.4	17.2	17.1	17.2	16.2
12-23	15.2	15.2	16.3	16.2	15.7	17.2	16.3	15.6

Sampling Depths, ft

B-1, 2, 3 — 1
B-1b — 2
B-2m — 3
B-2b — 6
B-3m — 4
B-3b — 8

APPENDIX B-13 (Continued)

TEMPERATURE AND OXYGEN LEVELS

4:00 P.M. and 5:00 A.M. in Lake No. 4

1962

	Nov. 6 PM		Nov. 7 AM		Nov. 13 PM		Nov. 14 AM	
	F°	D.O.	F°	D.O.	F°	D.O.	F°	D.O.
B-1	69	21.2	64	11.4	64	11	63	8
b	68	14.4	62	10.3	64	10.6	63	9
B-2	68	14.2	64	10.4	64	11	64	8.8
b	64	10	63	9.8	64	9.6	63	7.8
B-3	68	13.2	65	9.9	64	9.6	64	8.8
b	64	9	61	10.2	64	9.0	63	8.8

	Dec. 12 PM		Dec. 13 AM		Dec. 26 PM		Dec. 27 AM	
	F°	D.O.	F°	D.O.	F°	D.O.	F°	D.O.
B-1	60	16.2	58	15.2	58	23.8	56	14.2
b	60	17.6	57	14.8	58	24.1	56	14.2
B-2	59	14.2	58	15	57	20	56	14.4
m		14.6		15.2		18.4		13.6
b	58	11.7	57	14.2	56	15.2	56	14
B-3	59	16.8	58	15.2	58	20	56	14.6
m		15.6		15.7		18		14.4
b	58	14	56	14.6	56	15.8	56	14.1

1963

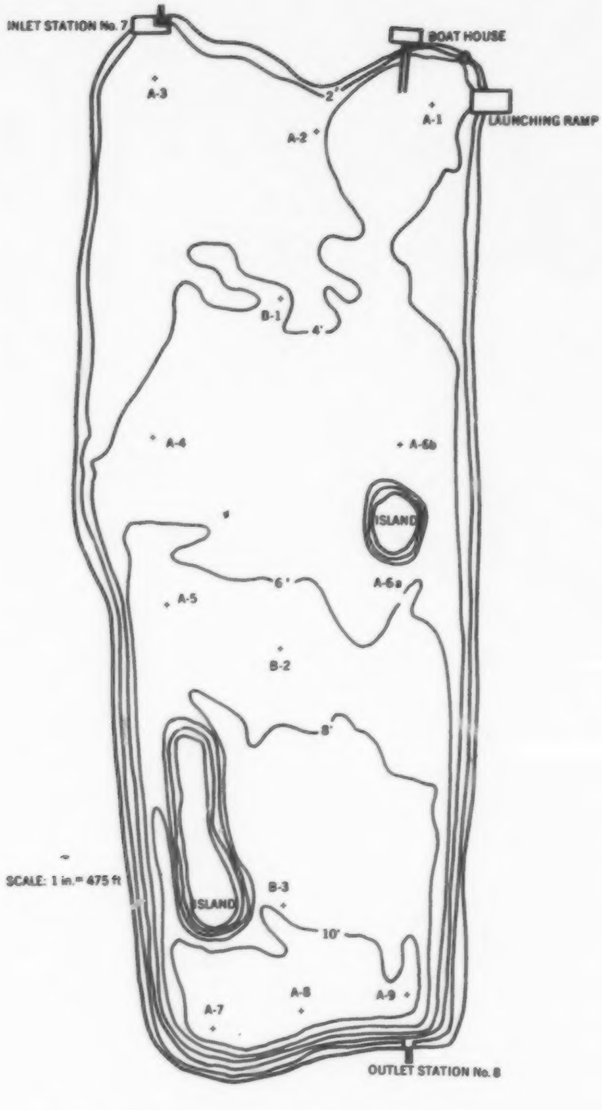
	Dec. 16 PM		Dec. 17 AM		Feb. 5 PM		Feb. 6 AM	
	F°	D.O.	F°	D.O.	F°	D.O.	F°	D.O.
B-1	52	24.6	47	17	62	25	60	19.4
b	52	24.4	47	17	63	25.6	60	18.9
B-2	51	24.4	47	17.6	63	34	60	19.2
m	50.5	23.6	47	17.6		29		19.6
b	48.2	21.4	47	17.6	64	18.6	58	19
B-3	51.5	24.4	47	17.8	66	30.8	60	19.4
m	51	21.4	47	17.8		28.4		19.8
b	48.5	17.4	47	17.8	61	18.2	58	13.8

APPENDIX B-13 (Continued)
TEMPERATURE AND OXYGEN LEVELS
4:00 P.M. and 5:00 A.M. in Lake No. 4

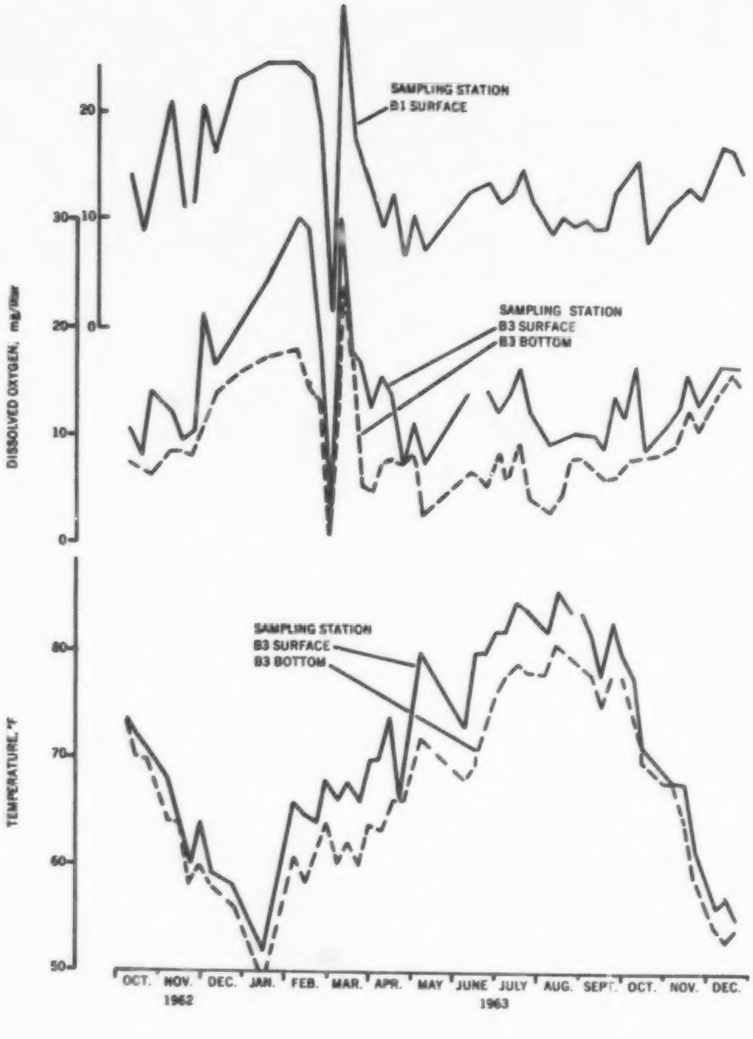
1963	Feb. 12 PM		Feb. 13 AM		Feb. 20 PM		Feb. 21 AM	
	F°	D.O.	F°	D.O.	F°	D.O.	F°	D.O.
B-1	61	24.2	58	15	64	19.2	61	16.4
b	61	23	58	15.2	64	18.6	61	16.2
B-2	63	26.6	58	14.2	64	20.2	61	16.4
m	63	25.6	58	14.2	64	19.6	61	16.6
b	58	22	58	14	62	16.4	61	16.2
B-3	64	29.4	58	15	64	19.4	61	16.4
m	61	25	58	13.8	64	19.4	61	16.4
b	58	15.2	58	13.6	61	13.4	61	16.2

	Feb. 26 PM		Feb. 27 AM		Apr. 3 PM		Apr. 4 AM	
	F°	D.O.	F°	D.O.	F°	D.O.	F°	D.O.
B-1	63	3.2	62	1.8	68	14.6	64	9.6
b	68	3	60	1.8	66	15.6	62	9.6
B-2	66	3.2	62	2.2	70	15.4	64	9.4
m	66	2.6	60	2.2	68	16	60	9
b	64	2	60	2	66	11.2	61	8.4
B-3	68	3	62	2.2	70	15.6	64	10.4
m	66	2.4	58	2	68	16.2	59	10.4
b	64	1	60	2	63	7.4	58	7.8

	May 1 PM		May 2 AM	
	F°	D.O.	F°	D.O.
B-1	77	9.2	72	3.7
b	76	9.2	72	3.5
B-2	76	9.4	72	4
m	74	9.4	71	4
b	72	9.6	71	3.7
B-3	76	9.6	72	3.8
m	72	9	71	3.7
b	70	5.4	70	1.5


INLET STATION No. 7
BOAT HOUSE
A-3
2'
A-1
LAUNCHING RAMP
A-2
B-1
4'
A-4
A-6b
ISLAND
6'
A-6a
A-5
B-2
8'
SCALE: 1 in.= 475 ft
B-3
ISLAND
10'
A-8
A-9
A-7
OUTLET STATION No. 8

Appendix B-14 — Sampling stations in Lake 4.



Appendix B-15 — Stratification of temperature and dissolved oxygen.

APPENDIX B-16

BENTHONIC ORGANISMS ASSOCIATED WITH THE SANTEE WATER RECLAMATION PROJECT

Progress Report

July 1962 — April 1964

by

H. I. Magy, Senior Vector Control Specialist
Bureau of Vector Control

I. Purpose

To determine whether a recreational facility using reclaimed sewage waste water can be operating without creating public nuisances from benthonic organisms.

II. Definition of "Benthonic" Organisms

For the purpose of this study, "benthonic" organisms are defined as macroscopic invertebrates living in bottom substrates of the Project waterways that can be collected and retained by a screen having openings of 0.5 mm. square. Examples of such organisms are: Chironomids, Chaoborids, Mollusks, Oligochaetes, Leeches. In actual practice this study has been concerned mainly with a study of the Chironomids although not of the benthos; mosquito breeding has been also studied and reported herein.

III. Objectives

A. To determine the numbers and species of the various benthonic organisms in the waterways of the Santee Water Reclamation Project.

B. To determine the seasonal variation of the population of these benthonic organisms.

C. To attempt to relate adult gnats collected with larval collections.

D. To develop control recommendations which could include chemical, biological, or environmental manipulations.

IV. Procedures and Techniques

A. *Sampling periodicity* — once every two weeks throughout the year; only three times in the 21 months of this study has this sampling period been altered, at which times the intervals were three weeks.

B. *Sampling stations*: 28 to 32 stations covering all (9) waterways (see Figure 1). The numbers have varied at the spreading basin, the intercepting basin, and the creek because of changes in water handling procedures. On occasion several of these waterways have gone dry.

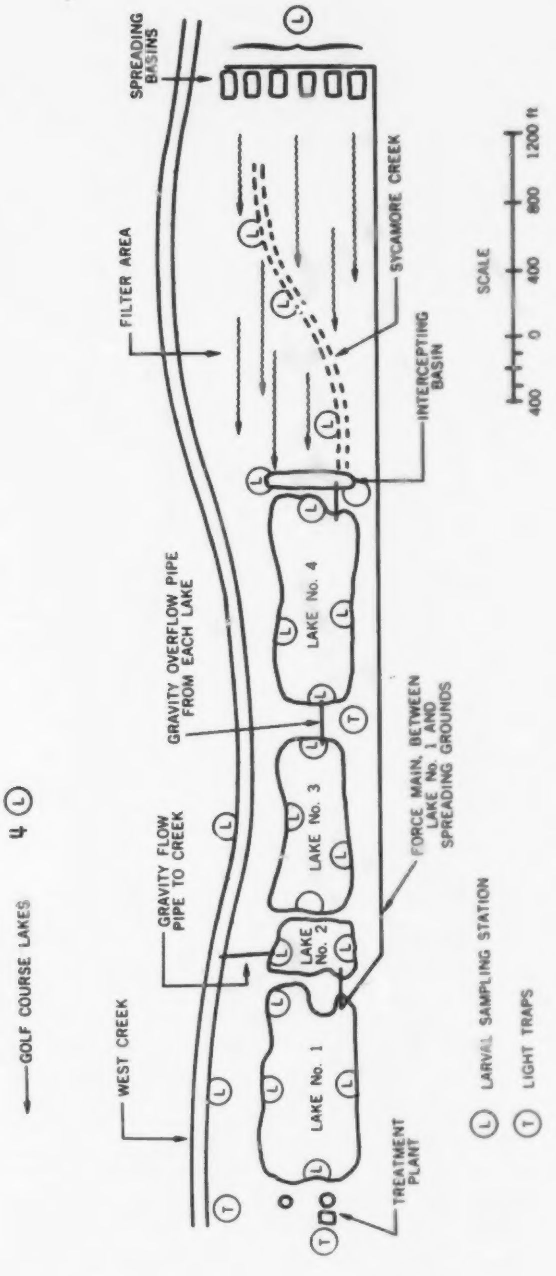

GOLF COURSE LAKES
4 L
WEST CREEK
GRAVITY FLOW PIPE TO CREEK
GRAVITY OVERFLOW PIPE FROM EACH LAKE
FILTER AREA
SPREADING BASINS
LAKE No. 1
LAKE No. 2
LAKE No. 3
LAKE No. 4
TREATMENT PLANT
FORCE MAIN, BETWEEN LAKE No. 1 AND SPREADING GROUNDS
INTERCEPTING BASIN
SYCAMORE CREEK
SCALE
400
0
400
800
1200 ft
L LARVAL SAMPLING STATION
T LIGHT TRAPS

Figure 1 — Diagram of reclamation lakes and filter area. Benthonic organisms survey.

C. *Equipment* — 6" mud scoop, sieve, midge counting tray and three light traps; sampling was limited to the edges of the waterways. In the above ground channel and in Sycamore Creek, samples were collected from three 4 - 6" diameter rocks at each sampling point. Light traps were placed in three different places at the Reclamation Project. See Figure 1 for the location of these traps.

D. *Field laboratory* — constructed at Reclamation Project in the winter of 1962 by the Santee County Water District and Bureau of Vector Control personnel.

E. *Identification* — samples of organisms are collected by Bureau of Vector Control personnel; field counts are made and tabulated. Representative samples are sent to our Berkeley office for identification purposes.

F. *Additional sampling* — during the summer of 1963 collections of adult midges in spider webs at nearby homes were made to determine which species were moving into residential areas.

G. *Personnel* — one-half time field man to do sampling, plus one-quarter time person used to compile data and for supervision.

V. Results and Observations

A. *Types of midge larvae and other benthonic organisms.* At least 12 species of midge larvae have been collected as shown in Table 1 from the various waterways. *T. stigmaterus* and *Pelopia* spp. were the most commonly collected species in Pond #1, which species are known to prefer water rich in organic matter, whereas in Ponds #3 and #4, almost all of the other species were found. An evaluation of the distribution of species by waterway and season will be made in the final report.

B. *Adult collections.*

1. *Light traps.* A review of the adult midges caught in the three light traps would indicate that only Trap No. 3 located between Ponds #3 and #4 reflected large population changes. This occurred during the summer of 1963 which data is not consistent with the larval count information when the larval count was low. The placement of these various traps and the movement of winds may likely have affected the numbers of midges being caught. There were 17 species of midges collected in light traps as shown in Table 2, or 4 more than were collected as larvae. It is possible that these gnats may have originated from some other source — or from a portion of waterways which were never sampled.

2. *Gnats found around homes.* Repeated samples of adult gnats collected in spider webs at three locations in the neighboring residential areas during the summer of 1963 demonstrated that all 13 species of gnat larvae that were collected were also found around homes. In discussing the discomfort and nuisances caused by gnats with residents, few were concerned with the gnats although mention was made that in previous years they were bothered by them.

3. ***Mosquitoes associated with the Santee Project.*** Mosquito larvae collected included *Culex pipiens*, *C. peus*, *C. tarsalis*, *Culiseta inornata* and *Anopheles franciscanus*. Intensive checking of the ponds was done during the fall of 1963 when considerable amount of manipulation of the waterways was undertaken by the District and significant places with mosquito breeding were found. These areas were in situations where the water was obstructed from the major bodies of water with either vegetation or barriers such as in the effluent area of Pond #1. Seepage pools within the area of Pond #5, which was under construction, and adjacent to the intercepting basin frequently had mosquitoes. The spreading basins, although dried frequently, often had residual pools which were capable of breeding mosquitoes. These mosquitoes were usually promptly brought under control through the efforts of the San Diego County Health Department Mosquito Spray Crew and also the operators of the Santee Water District when they were brought to the attention of the District.

C. *Distribution of gnats within Ponds #4 and #1.* Extensive sampling through the centers and sides of Ponds #1 and #4 demonstrated that in Pool #1 which receives the effluent from the activated sludge, midge larvae were usually absent from the centers but were found in large numbers around the edges. Sampling was therefore limited to the edges of that Pond. Similar studies on Pond #4 demonstrated that midges were found fairly evenly distributed throughout the Pond although difficulty was encountered using an Eckmann dredge as the initial sampling device. Consequently, sampling on all waterways with the exception of the streams was done by the use of the 6″ sieve, and was restricted to the edges.

D. *Relative abundance of gnats within waterways.* Table 3 is a tabulation of the number of collecting periods when each waterway had an average of 1000 or more gnat larvae per square foot. It can be seen that Ponds #1 and #2 and West Creek, which receives effluent from Pond #2, had the highest count which may be attributed to the large amount of nutrients available in these Ponds. Ponds #3 and #4 had the lowest gnat count which could reflect a lower level of nutrients.

E. *Seasonal variation within waterways.* All of the waterways except Ponds #3 and #4 have had major manipulative changes during the period of this study and for this reason we are limiting our comments on the effect of seasonal variation to these two ponds. A review of Figures 2 and 3 indicates that during the Fall of 1962 the population of midges was fairly high, possibly reflecting the relatively low level of biological control by predators and midge pathogens because of the youthfulness of the ponds. Following an autumnal drop that year there was a buildup during the winter of 1962-63, followed by a summer drop and another population rise in the winter of 1963-64. The gnat larval population count in these ponds seemed to be inversely related to the mean air temperature — which was contrary to our expectations. A complete picture of the cyclic population developments will be available following gnat counts to be taken through June 1964.

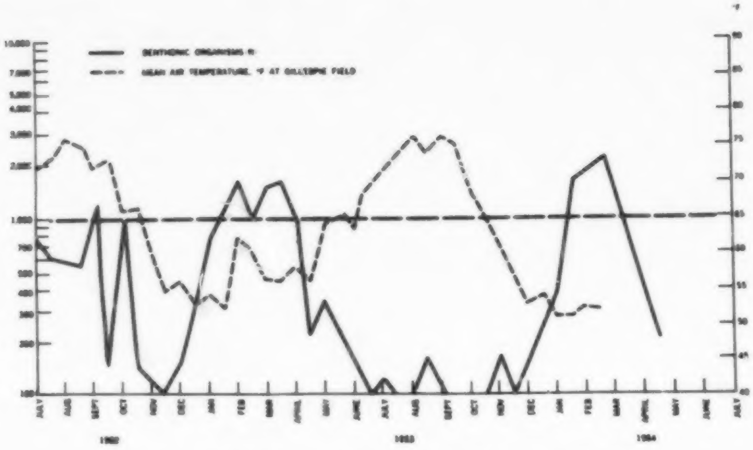


Figure 2 — Air temperature vs. benthonic organisms. Pond No. 4.

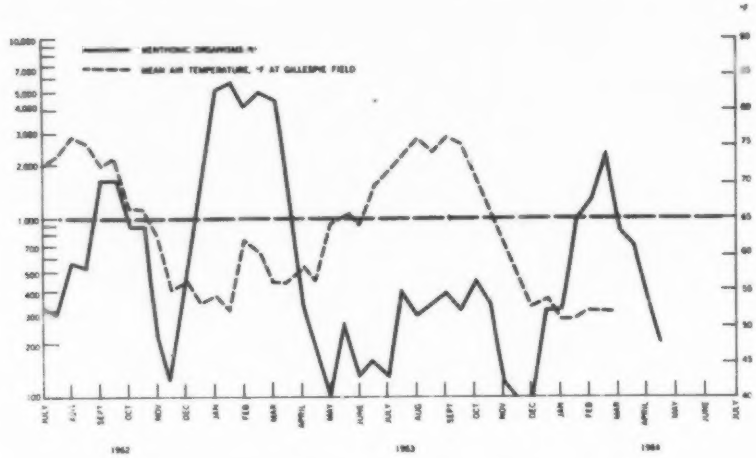


Figure 3 — Air temperature vs. benthonic organisms. Pond No. 3.

F. *Variables influencing gnat population in waterways.* Since midges feed upon plankton the growth of which in turn is influenced by the dissolved oxygen and the temperature, any unusual circumstance affecting these variables undoubtedly would have had an effect upon the population of the midges. It was beyond the scope or the intent of this study to try to determine what these interrelations were. Nevertheless, the extreme variations in the midge population at times could possibly be explained as being the result of the influence of one or several of these factors. Fortunately, water temperature at the one-foot depth and the dissolved oxygen was studied in Ponds #1 and #2 by the U. S. Public Health Biologist.

During the summer of 1963 (see Figures 2, 4 and 5) the population of midges in Pond #4 dropped significantly which might relate to an increase in the air and water temperature and a depression of the dissolved oxygen level. However, this situation did not occur in Pond #1 except for the week of August 26 when the pond began to turn septic (Figure 6). It is of interest to note that the sampling station in Pond #1 located nearest to the outlet of the effluent from the treatment plant had the lowest count of the stations in that pond throughout the study. The rationale for these differences will be presented in the final report.

VI. Future Activities

The present phase of the study will be terminated at the end of the current fiscal year on June 30. We will then make periodic appraisals of the Project waterways to obtain specific information to help clarify some of the population data that we have obtained.

A more detailed and comprehensive report will be made available at the conclusion of this phase of the study on June 30.

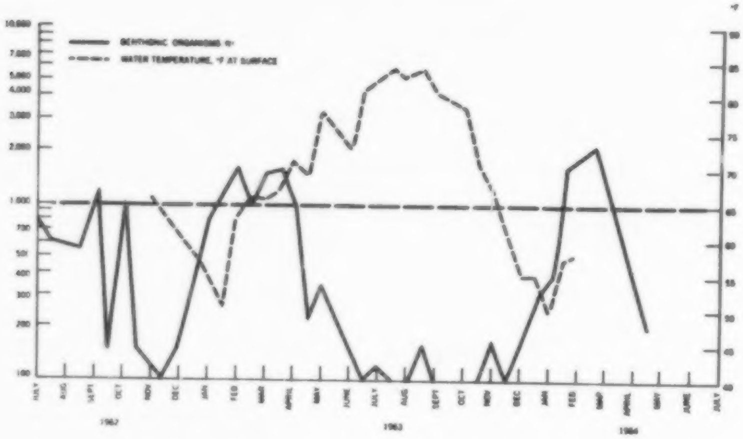


Figure 4 — Water temperature vs. benthonic organisms. Pond No. 4.

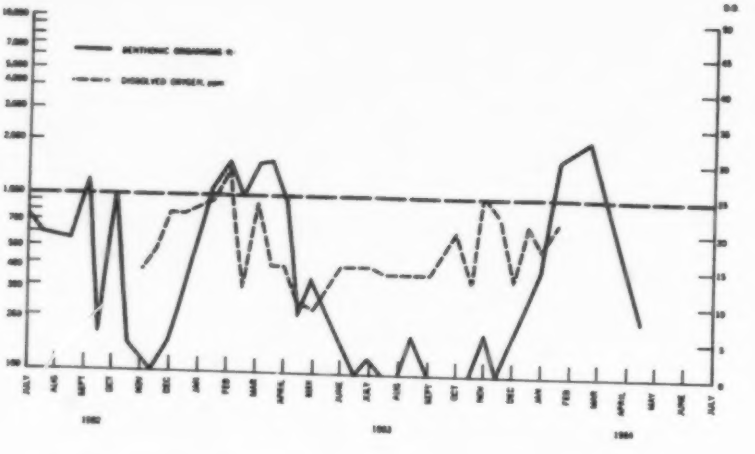


Figure 5 — Amounts of dissolved oxygen vs. benthonic organisms. Pond No. 4.

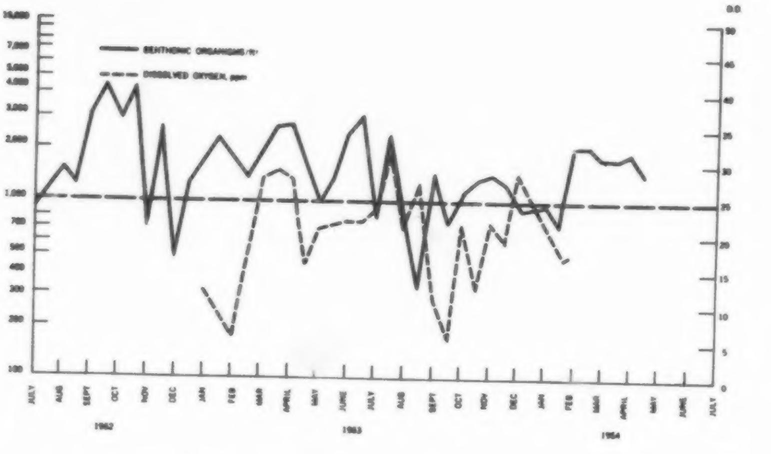


Figure 6 — Amounts of dissolved oxygen vs. benthonic organisms. Pond No. 1.

Table 1

Benthonic Organisms Collected
Santee Water Reclamation Project

Larval Collections

Tendipedidae (Midges)

- *Tendipes fulvipilos*
  - *T. stigmaterus*
  - *T. attenuatus*
  - *T. nervosus*
  - *T. plumosus*
  - *T.* (*Dicrotendipes*) *californicus*
  - *T.* (*Chryptochironomus*) sp.
- *Polypedilum* sp.
- *Tanytarsus* sp.
- *Pelopia* sp.
- *Procladius* sp.
- *Pentaneura* sp.

- *Cricotopus* sp.

Chaoboridae (Phantom gnat)
- *Chaoborus* sp.

Heliidae
Simuliidae (Buffalo gnat)
- *Simulium argus*
  - *S. vittatum*

Tabanidae
Ephemeroptera
Mollusca
- *Physa* sp.

Annelida
- *Limnodrills* sp.
- *Tubifex* sp.

Amphipoda

Table 2

Adult Tendipedidae and Other Insects Collected at Light Traps Located at Santee Water Reclamation Project

- Tendipedidae
  - *Tendipes fulvipilos*
    - *T. Stigmaterus*
    - *T. attenuatus*
    - *T. californicus*
    - *T. nervosus*
    - *T. plumosus*
    - *T.* (*Cryptochironomus*) *monochromus*
  - *Endochinonomus nigricans*
  - *Polypedilum parvum*
  - *Tanytarsus* sp.
  - *Cricotopus* sp.
  - *Pelopia* sp.
  - *Procladius* sp.
  - *Pentaneura* sp.
  - *Anatopynia* sp.
  - *Micropsectoa* sp.
  - *Smittia* sp.
  - Unidentified — several species
- Chaoboridae
  - *Chaoborus punctipennis*
- Psychodidae
  - *Telmatoscopus furcatus*
  - Unidentified psychodids
- Heliidae
  - *Culicoides* sp.
- Culicidae
  - *Culex* sp.
  - *Culiseta* sp.
  - *Anopheles franciscanus*

Table 3

Relative Chironomid Larvae Productivity of Santee Waterways*

Waterway	No. Collections with Average of 1000+ per sq. ft.	Gnat Product. Status
Pond #1	34	1
Pond #2	28	2
Pond #3	10	6
Pond 4	8	8
Intercepting Basin	9	7
Sycamore Creek	14	5
Spreading Basin	4 (dry 19 out of 45 times)	—
West Creek	27	3
Golf Course Lakes	22	4

*Maximum of 45 collection periods to date — Week of April 6, 1964.

GPO 804-840-9

State of California — Health and Welfare Agency
DEPARTMENT OF PUBLIC HEALTH
217 West First Street, Room 706
Los Angeles 90012

November 18, 1965

Mr. John Merrell, Sanitary Engineer, U.S.P.H.S.
San Diego County Health Department
1600 Pacific Highway
San Diego, California 92101

Dear John:

As requested, we have made a midge larval survey of the Santee Water Reclamation impoundment during the week of November 1st. Attached is a summary of our findings. For comparative purposes, the data for the same week in 1962 and 1963 are given.

The larval population for this period appears to be within variations experienced in 1962 and 1963, although on the average higher. This may be due to the large numbers collected from the single sample from North Sycamore Creek.

Should you wish to make additional evaluations, please feel free to contact me.

Sincerely yours,
Richard F. Peters, Chief
BUREAU OF VECTOR CONTROL
Harvey I. Magy
Southern California
Area Representative

HIM: al
Attachment
cc. J. B. Askew, M.D.

AVERAGE NUMBER OF CHIRONOMIDAE LARVAE PER SQ. FT. SANTEE WATER RECLAMATION STUDY

Location	Number of Samples	Week of 10-28-62	11-4-63	11-1-65
Pond #1	4	700	1,400	1,740
Pond #2	3	2,600	800	1,840
Pond #3	4	510	200	660
Pond #4	4	112	160	190
Pond #5	3	....	....	50
N. Sycamore Creek	2	360	120	1,470*
Sycamore Creek	3	1,200	1,200	1,680
Golf Course Lakes	4	750	2,050	2,350
Average		890	833	1,330**
Range		112-2,600	120-2,050	190-2350

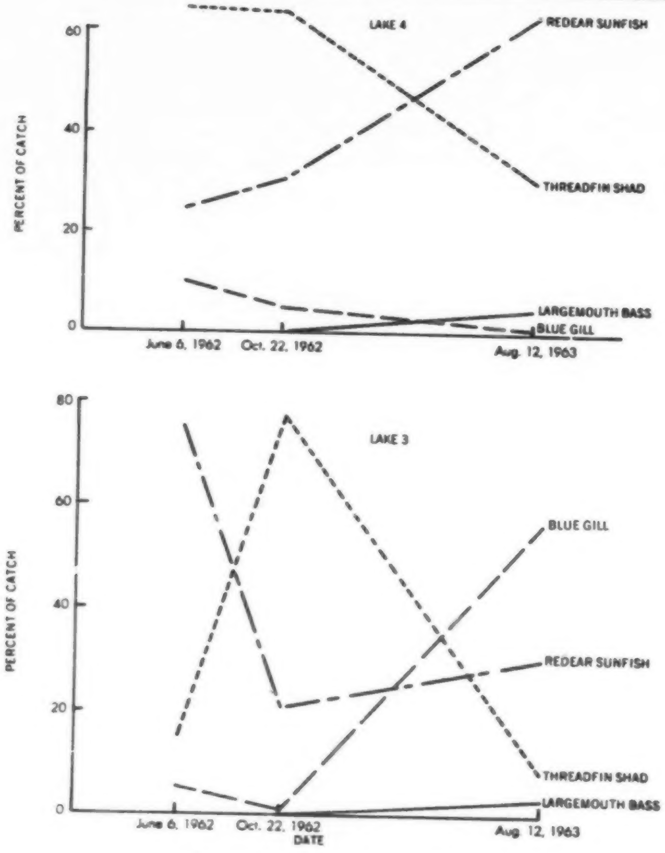
*Only one sample taken.

**Average does not include count from Pond #5.

APPENDIX B-17
MODAL SIZE OF FISH IN inches.

LAKE 3

Date	Largemouth Bass	Threadfin Shad	Redear Sunfish	Bluegill Sunfish
6- 6-62			3.8	
10-22-62		1.4	4.6	
8-12-63	2.5 and 13	2.6	4.8	3.4
LAKE 4				
6- 6-62			2.8	
10-22-62		1.8	3.6	
8-12-63	4.0	3.2	4.2	



Composition of fish seining catch.

APPENDIX B-18

PHYSICAL AND CHEMICAL QUALITY OF TREATMENT

Quality of Activated Sludge
Mixed Liquor

Month	Sup. Solids mg/liter	% Settleable	Sludge vol. index ml/gm	D.O. mg/liter
Feb 1962	6,140	84	137	1.0
May	5,950	88	148	1.2
Aug	7,330	97	132	1.1
Nov	6,080	72	118	0.9
Apr 1963	5,000	88	176	2.5
July	3,680	35	95	1.3
Oct	5,930	57	96	0.6
Jan 1964	5,510	47	85	1.0

Suspended Solids, mg/liter

Location	Total		Volatile		Fixed
	Range	Avg	Range	Avg	Avg
Plant inlet	120 to 1,970	580	105 to 1,849	501	79
Primary effluent	105 to 1,980	500	33 to 1,877	404	96
Secondary effluent	23 to 314	62	10 to 250	54	8
Pond effluent	17 to 173	69	17 to 129	55	14
Lake inlet	0 to 40	8.6	0 to .20	4.2	4.4
Lake outlet	1 to 29	13	1 to 15	8.3	4.7

Range of Quarterly Averages (of total dissolved solids, pH, and Alkalinity)

Location	TDS mg/liter		pH		Alkalinity mg/liter	
	Range	Avg	Range	Avg	Range	Avg
Plant inlet	940 to 1,305	1,125	6.9 to 7.8	7.3	240 to 481	322
Primary effluent	970 to 1,255	1,124	6.1 to 7.9	7.3	252 to 404	353
Secondary effluent	1,030 to 1,160	1,080	6.6 to 7.9	7.3	268 to 368	314
Pond effluent	914 to 1,165	1,091	7.3 to 9.1	8.3	224 to 349	261
Ground 6.0	448 to 713	621	6.3 to 7.6	6.9	40 to 86	54
Ground 6.1	974 to 1,285	1,080	7.1 to 7.4	7.3	233 to 318	270
Ground 6.2	773 to 1,240	959	6.8 to 7.6	7.2	98 to 225	166
Lake 4 inlet	370 to 1,145	1,014	7.0 to 8.1	7.6	80 to 236	194
Lake 4 outlet	845 to 1,320	1,101	7.5 to 9.0	8.3	138 to 239	197

GPO 804-840-10